Chapter 4 — Environmental Consequences

This chapter of the EIS provides an analysis of the effects (environmental consequences) that would result from implementation of the Proposed Action and alternatives. An environmental effect or consequence is defined as a modification or change in the existing environment brought about by the action taken. Effects can be direct, indirect, or cumulative in nature and can be temporary (short term) or permanent (long term). Effects can vary in degree ranging from only a slight discernable change to a drastic change in the environment. For the purpose of this EIS, short-term effects are defined as those that would occur during the construction and drilling/completion phases. Long-term effects are those caused by construction and operations that would remain longer.

The effects analysis evaluated the effects that would occur in the Project Area, regardless of land ownership. However, the BLM and FS' decisions on this Project would only apply to federal lands. The effects reported for non-federal lands may occur regardless of the BLM and FS' decisions. Effects on non-federal lands are included to provide a full disclosure of effects for the complete Project and to support other environmental permitting associated with the Project.

Groundwater

During CBM development, a portion of the water contained in the coal aquifer is removed from CBM wells as produced water. The primary effects on groundwater resources would be associated with the removal of groundwater stored within coal seams and the subsequent recharge of aquifers through infiltration or injection of produced water. The combined effects of coal mining activities and other existing or reasonably foreseeable conditions on groundwater resources also are described within this chapter.

The effects of CBM development on groundwater resources would be seen as a drop in the water level (drawdown) within nearby water wells completed in the developed coal aquifers and underlying or overlying sand aquifers. Drawdown is observed when a loss in hydraulic pressure head occurs in the developed coal aquifers or in the overlying and underlying sand aquifers. The hydraulic pressure head is the vertical distance between the water level in a water well and the top of the confined aquifer in which the well is completed.

Partial removal of groundwater from a coal seam (through coal mining operations or CBM development) would reduce the hydraulic pressure head and create a hydraulic gradient toward the well or excavation. As groundwater flows into a pumping well or excavation, there would be a progressive decline in hydraulic pressure head with time and distance. The effects would be seen as progressive declines in the water level (drawdown) within nearby water wells completed in and near the developed coal aquifers.

Infiltration of produced water would initiate recovery in nearby water wells. However, continued leakage of infiltrated produced water from overlying and underlying sands into the coals would delay noticeable recovery of the sands until water removal ends. After water removal ends, water levels in nearby water wells would be expected to recover. The rate of recovery initially would be rapid due to re-equilibration of pressure heads within the coal and leakage from overlying and underlying units. The rate of recovery in the coal and sand aquifers would decrease progressively during the recovery period, as the enhanced infiltration of produced water declines.

Other potential effects on existing water wells would include changes in water yield, quality, or methane emissions. Other effects on groundwater resources would consist of potential changes in the nature of groundwater discharge to the surface or recharge to the aquifers. The nature of groundwater discharge to the surface as springs, seeps, or base flows of surface drainages could change. Surface discharge of extracted groundwater from CBM operations into surface drainages, flow-through stock reservoirs, upland or bottomland infiltration impoundments, or upland containment impoundments would enhance recharge of shallow aquifers below creek and impoundment areas. Injection of CBM produced water would recharge the aquifer units in which the injection wells are completed.

Hydrogeologic Groups

A detailed description of the geology and hydrology of the area is given in Chapter 3. This analysis focuses on the coal seams of the upper part of the Fort Union Formation, the sands of the overlying Wasatch Formation, and the alluvium underlying surface drainages.

The Wasatch Formation is exposed at the surface over most of the Project Area and overlies the Fort Union Formation. The Wasatch Formation consists of fine-grained sandstones, siltstones, claystones and coals. The sandstones tend to be discontinuous but locally are utilized for water supply. Coal zones generally are not economic for mining, or CBM development except in the area of Lake De Smet near the western margin of the PRB. Siltstones and claystones typically have low permeability and form hydraulic confining units (or aquitards) within the Wasatch sequence.

The Fort Union Formation consists of coals, sandstones, siltstones, and claystones. The coals of the upper Fort Union Formation show great variation in thickness and continuity over the PRB. Coal seams split and merge over distances of a few miles so that it is more appropriate to consider the coals as part of a hydrogeologic group rather than as individual aquifers. For the purpose of this analysis, the upper sequence of the Fort Union Formation has been subdivided into four hydrogeologic groups defined on the basis of the stratigraphic correlation of coal seams (Goolsby and Finley 2000).

All four coal groups are identifiable in the northern part of the PRB. Groups 1, 2, and 3 merge to form a thick coal unit, known as the Big George, in the central portion of the PRB. Only Group 4 is present in the southeastern part of the PRB, where it is locally known as the Wyodak coal. The outcrop areas of the coal seams are characterized by the presence of highly permeable clinker that forms an important recharge area for the coal.

Groundwater Assumptions

Recharge to groundwater aquifers occurs from direct infiltration of precipitation (rain and snowmelt), runoff in creek valleys and standing water in playas. Infiltration is significant in areas of more permeable surface geologic units such as sandstone, or the clinker occurring in outcrop areas of the Fort Union and Wasatch Formations. Direct infiltration of precipitation provides a minimal source of recharge over most of the area because the climate and surface features prohibit significant infiltration. However, infiltration of surface water in creek valleys is considered an important source of recharge to the underlying alluvium and the shallow bedrock aquifers.

A USGS study of two ephemeral drainages in the southern part of the PRB indicated stream losses of between 0.43 to 1.44 acre-feet per mile from individual storm runoff events (Lenfest 1987) and these values were acknowledged to be underestimated. Recharge to shallow aquifers from stream valleys ranged from 3.56 to 26.5 acre-feet per mile for individual storm runoff events in the same study. Recent studies of surface water losses occurring in several drainages of the PRB receiving CBM produced water during dry weather conditions indicate that conveyance losses range from 64 percent to 100 percent of inflows (Meyer 2000, AHA and Greystone 2001, Babb 1998).

Conveyance losses include both evapotranspiration and leakage into alluvium and bedrock underlying the streams. Evapotranspiration varies seasonally, but probably accounts for less than 20 percent of the conveyance losses over the course of a year. A monthly water balance calculation for the Wild Horse Creek drainage found that evapotranspiration accounted for approximately 18 percent of the conveyance loss associated with the surface discharge of CBM produced water within the drainage basin (Hydrologic Consultants Inc. 2001). Recharge of shallow aquifers due to leakage from rivers or streams is likely to account for over 80 percent of the conveyance loss.

For the purpose of this analysis, discharge of CBM produced water to surface drainages is assumed to result in an 80 percent conveyance loss, 82 percent of which is due to infiltration and 18 percent due to evapotranspiration. These values are averaged from various studies of surface water losses in creek flows in several drainages of the PRB (Meyer 2000, AHA and Greystone 2001, Babb 1998, Lenfest 1987) and result in an estimated net recharge to shallow groundwater of almost 66 percent of the water produced.

For the purpose of this analysis, where produced water would be discharged to infiltration impoundments designed to allow infiltration, water would infiltrate at an estimated rate of eight feet per year. This estimated infiltration rate is used in the groundwater impact analysis to ensure that the environmental effects that could result from substantial infiltration of produced water are considered in the groundwater model analysis. There would be no evapotranspiration of this infiltration water so that the net recharge to shallow groundwater would be 100 percent of the produced water that infiltrates the surface.

For the purpose of this analysis, where produced water would be discharged to large containment impoundments constructed in a manner that allows minimal infiltration, an estimated 10 percent of the water stored in these reservoirs would infiltrate the surface. There would be no evapotranspiration of this infiltration water so that net recharge to shallow groundwater would be 10 percent of the produced water discharged into containment impoundments.

For the purpose of this analysis, all of the produced water used for land application would be used consumptively. There would be no net recharge from this water handling option.

Injection of CBM produced water results in recharge to the zone of injection. For purpose of this analysis, injection is assumed to be deep injection (such as into the sands of the lower Fort Union Formation). There would be no net recharge to the Wasatch sands or the coal zones within the Fort Union Formation from this water handling option.

Groundwater assumptions and the fate of the CBM-produced water are summarized by alternative in Table 4–1, Table 4–2, and Table 4–3.

Hydraulic connection between the sands of the Wasatch Formation and the coals of the upper Fort Union Formation is limited due to the low permeability claystones that separate the two units. However, if the hydraulic head (water level) in the coal is naturally lower than in the overlying sands, then there is potential for leakage from the sands into the coal. Based on observation of water levels in nested monitoring wells, significant leakage into developed coals is only expected where Wasatch sands occur within approximately 100 feet above or below the coal zone. The natural leakage rate typically would be extremely small, but taken over a large area can amount to a significant portion of the total recharge into the coal.

As sands in the Wasatch Formation tend to be discontinuous, the amount of leakage would also be limited by the areal extent of sands that exist within 100 feet of the coal. Locally, the hydraulic connection between the coal and Wasatch sands may be enhanced if the integrity of the confining layer is compromised by water supply wells screened through both the coal and the overlying sands, deteriorating well casings, or poorly plugged oil and gas wells or exploratory drill holes. Leakage from the Wasatch sands into the coal also may be enhanced if water levels in the coal are lowered as a result of coal dewatering activities. Due to the limited hydraulic communication between the coal and the overlying Wasatch sands, a significant period of time (typically several years) would likely pass before noticeable drawdown (drop in water level) in the sands would be apparent.

Table 4–1 Groundwater Assumptions and the Fate of the CBM-Produced Water for Alternatives 1 and 3

	Surface Discharge				Infiltration		Containment			LAD	Injection
Sub-watershed	Runoff (Percent)	Infiltration (Percent)	Evapotranspiration (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Consumptive Use	Deep Recharge
Upper Tongue River	7	23	5	0	30	15	3.8	1.0	5.2	0	10
Upper Powder River	15	49	11	0	10	5	1.9	0.5	2.6	0	5
Salt Creek	11	36	8	0	23	12	1.9	0.5	2.6	0	5
Crazy Woman Creek	14	46	10	0	3	2	1.9	0.5	2.6	15	5
Clear Creek	7	23	5	0	27	13	1.9	0.5	2.6	10	10
Middle Powder River	13	43	9	0	7	3	3.8	1.0	5.2	10	5
Little Powder River	13	43	9	0	7	3	3.8	1.0	5.2	10	5
Antelope Creek	11	36	8	0	23	12	1.9	0.5	2.6	0	5
Upper Cheyenne River	11	36	8	0	23	12	1.9	0.5	2.6	0	5
Upper Belle Fouche River	9	30	6	0	27	13	1.9	0.5	2.6	0	10

Table 4–2 Groundwater Assumptions and the Fate of the CBM-Produced Water for Alternative 2A

	Surface Discharge				Infiltration		Containment			LAD	Injection
Sub-watershed	Runoff (Percent)	Infiltration (Percent)	Evapotranspiration (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Consumptive Use	Deep Recharge
Upper Tongue River	2	7	1	0	40	20	3.8	1.0	5.2	10	10
Upper Powder River	5	16	4	0	37	18	1.9	0.5	2.6	10	5
Salt Creek	0	0	0	0	40	20	3.8	1.0	5.2	5	25
Crazy Woman Creek	2	7	1	0	40	20	3.8	1.0	5.2	10	10
Clear Creek	2	7	1	0	40	20	3.8	1.0	5.2	10	10
Middle Powder River	5	16	4	0	34	17	3.8	1.0	5.2	10	5
Little Powder River	5	16	4	0	34	17	3.8	1.0	5.2	10	5
Antelope Creek	8	26	6	0	27	13	1.9	0.5	2.6	10	5
Upper Cheyenne River	8	26	6	0	27	13	1.9	0.5	2.6	10	5
Upper Belle Fouche River	9	30	6	0	20	10	1.9	0.5	2.6	10	10

Table 4–3 Groundwater Assumptions and the Fate of the CBM-Produced Water for Alternative 2B

	Surface Discharge				Infiltration		Containment			LAD	Injection
Sub-watershed	Runoff (Percent)	Infiltration (Percent)	Evapotranspiration (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Storage (Percent)	Infiltration (Percent)	Evaporation (Percent)	Consumptive Use	Deep Recharge
Upper Tongue River	7	23	5	0	23	12	3.8	1.0	5.2	10	10
Upper Powder River	8	26	6	0	27	13	1.9	0.5	2.6	10	5
Salt Creek	0	0	0	0	40	20	3.8	1.0	5.2	5	25
Crazy Woman Creek	6	20	4	0	30	15	1.9	0.5	2.6	10	10
Clear Creek	6	20	4	0	30	15	1.9	0.5	2.6	10	10
Middle Powder River	9	30	6	0	20	10	3.8	1.0	5.2	10	5
Little Powder River	9	30	6	0	23	12	1.9	0.5	2.6	10	5
Antelope Creek	10	33	7	0	20	10	1.9	0.5	2.6	10	5
Upper Cheyenne River	10	33	7	0	20	10	1.9	0.5	2.6	10	5
Upper Belle Fouche River	10	33	7	0	17	8	1.9	0.5	2.6	10	10

Partial isolation of the sand aquifers overlying the coal is indicated in the results of the BLM groundwater monitoring of the Marquiss CBM project, which has had the longest history of operation (since 1993). The BLM has monitored two paired wells since the beginning of the project. MP-22C is completed in the coal and MP-22S completed in the first overlying sand zone, approximately 40 feet above the coal. Water level decline of over 250 feet has been observed in the coal monitoring well, while a water level decline of approximately 20 feet has been observed in the overlying sand aquifer, after more than eight years of monitoring. For the purpose of this analysis, the partial isolation of the sand aquifers overlying the coal that has been documented by BLM monitoring is assumed to apply to this analysis.

Through time, many clinker deposits have become saturated as a result of the infiltration of precipitation and snowmelt. “Ponding” of water may occur along the interface where clinker meets less permeable coal and sediments of the Wasatch Formation. Springs may form at the base of the clinker deposits. Moyer Springs, located north of Gillette, is a good example of this type of occurrence.

Regional groundwater flow in the eastern part of the PRB is generally to the northwest (downdip) towards potential discharge areas in the north central part of the PRB (Daddow 1986). Coal wells in the vicinity of the Powder River exhibit flowing artesian conditions indicative of upward flow gradients. This supports the potential for groundwater discharge along the northern part of the Powder River, although physical evidence for this, in the form of springs and sustained river base flow, are not readily apparent. It is assumed that most of the discharge is diffuse and may be consumed by evapotranspiration so that it does not appear as surface flow. A significant portion of deeper groundwater flow in the PRB probably discharges farther north, into the Yellowstone River drainage basin.

Groundwater Modeling Methodology

Numerical groundwater flow modeling was used to predict the impacts of the Project. Modeling was necessary because of the large extent, variability, and cumulative stresses imposed by mining and CBM development on the Fort Union and Wasatch aquifer units. Assessment of CBM development impacts has been performed for earlier environmental assessments for the Marquiss, Lighthouse, North Gillette, and South Gillette areas (BLM 1992a, 1995a, 1995b, 1996, and 1997a). A detailed modeling study was completed for the Little Thunder drainage basin in the southeastern part of the PRB (Wyoming Water Resources Center 1997). Modeling of the eastern part of the PRB was performed for the Wyodak EIS (BLM 1999e). The information from earlier studies was reviewed and has been incorporated wherever practical into the modeling work for this analysis.

The computer model used to complete the groundwater analysis for this Project is briefly described here. The complete technical description of this groundwater analysis is found in the *Technical Report for the Powder River Basin Oil and Gas Project, Groundwater Modeling of Impacts Associated with Mining and Coalbed Methane Development in the Powder River Basin (*AHA and Greystone 2001), on file at the BLM Casper Field Office in Casper, Wyoming and at the BLM Buffalo Field Office in Buffalo, Wyoming. This report describes the specific hydrogeologic data on which the model was based. It also describes the numerical model and model assumptions in more detail.

The hydrogeologic model code selected was the USGS Three Dimensional Finite Difference Modular Groundwater Flow Model MODFLOW-98. This model code is widely accepted by regulatory agencies and currently is used by the BLM.

The regional model consists of 17 layers. The lowermost three layers (layers 15, 16, and 17) represent the lower members of the Fort Union Formation and the claystone aquitard separating these members from the overlying coals in the upper portion of the Fort Union Formation. The coal-bearing units of the upper portion of the Fort Union Formation are represented by layers 8, 10, 12, and 14 in the model. The intervals between the coal-bearing units are represented by layers 9, 11, and 13. As the coal-bearing units split and merge in the PRB, the hydraulic properties assigned to the layers representing both coal-bearing units and intervening units would change accordingly. The coal-bearing units transition into more highly permeable clinker in outcrop areas. Overlying the four coal-bearing units is a layer (layer 7) representing claystones within the Wasatch Formation that act as a confining unit between the coal-bearing units and the discontinuous sandstones within the Wasatch Formation. Layers 1 through 6 represent the Wasatch Formation, consisting of alternating layers of discontinuous sandstone units and claystone/siltstone units. The discontinuous nature of the sandstones in the Wasatch Formation was modeled by assigning hydrologic parameters to these layers that are representative of mixed sandstone and claystone/siltstone units. The uppermost layer (layer 1) represents surface geologic units, including claystones, sandstones, and alluvial sediments within creek valleys.

Other geologic boundaries that were incorporated into the model include faults and lineaments where these are suspected of having a significant influence on groundwater flow regimes. Faults may act as impermeable (no-flow) boundaries or zones of flow restriction, and lineaments as zones of augmented hydraulic conductivity in the model.

For geographic locations where mining would occur, the mining sequence was simulated as incremental impacts in one-year stress periods from approximately 1975 (the earliest mining along the Wyodak outcrop, with the exception of the Wyodak mine located east of Gillette) to the present. Predictive simulations of impacts were modeled to 2225, approximately 200 years beyond the end of reasonably foreseeable mine plans, in 2021. Historic mining records and life-of-mine plan maps on file with the Wyoming Department of Environmental Quality in Cheyenne were used to develop historic mine sequences and to project the approximate future mining sequence. Although life-of-mine plans are dynamic and may change in future years, they give a general projection of likely coal removal sequences and mine progression. Annual progress of the mine plans was superimposed on the grid as drains within the model, with the pits left open for three years and then closed. Mining drains are set with drain elevations positioned just above the base of the mined coal seam. When mined areas are reclaimed, the drains are removed from the model so that water levels can recover.

Current CBM production was simulated in the area using the historic operational data from the existing fields. Future CBM development was simulated using the estimate of future development described in Chapter 2. Annual progress of CBM development was simulated as drains within the appropriate model cells. These drains were set at an elevation of approximately 50 feet above the top of the developed coal seam. Historic CBM production sequences were simulated using water production data available from the WOGCC. Future CBM water production estimates assumed an average operational life of seven years for each projected CBM well.

Model calibration was done to pre-mining water levels, or in a few cases, earliest available static water levels. This was assumed to represent steady state conditions. The model was calibrated in transient state by matching against available historic water level monitoring data and CBM well production data. Sources of the water level monitoring data used to calibrate the model include Daddow (1986), the Gillette Area Groundwater Monitoring Organization (GAGMO), individual mine data, and the BLM.

The groundwater flow model was used to predict the areal extent of aquifer drawdowns due to the superimposed stresses of the proposed CBM development and mining operations on a year-by-year basis. CBM development of the PRB began in 1989. The Rawhide Butte field represented the first commercial CBM production in the PRB. Considerable CBM development has occurred in the Marquiss and Lighthouse areas south of Gillette, and in the vicinity of the Buckskin and Eagle Butte mines north of Gillette. Information from the WOGCC database indicates that as of May 2001 there were 5,854 producing CBM wells and an additional 2,520 shut-in wells in the PRB. The approximate locations and timing of CBM development through 2001 were input into the model based on actual well records. The location and timing for future CBM development were based on permit applications and projections contained in Chapter 2.

The following information used in the model analysis is described in Chapter 2. New CBM wells are projected by year and sub-watershed. The proportion of CBM produced water that would be handled using discharge to surface drainages, infiltration, containment, land application, and injection also is projected for each sub-watershed.

The model used water production data from the WOGCC as the source for input of drains. It is assumed that future wells would be drilled over a ten-year period from March 2002 through March 2012 and each would have a seven-year life span as described in Chapter 2. A total of 39,367 new wells were input into the model as drain nodes with appropriate time schedules. The producing intervals of the wells were distributed among the four coal-bearing units (layers of the model) based on existing production or the thickness and depths of the coals in any given area. In many areas, more than one coal interval would be produced, and this is reflected in the model where more than one well per well pad is projected.

The effects of the various water handling methods were simulated in the model by applying additional recharge to the portion of each sub-watershed affected by CBM development, on a year-by-year basis during the production period. The recharge amount was based on modeled water production, the projected proportion of water handled by the various methods, and the projected infiltration associated with each water handling method. The additional recharge was converted to a year-by-year infiltration rate based on the area of CBM development in each sub-watershed.

Alternative 1

The following discussion outlines the projected effects on water yield, and aquifer characteristics or conditions, including groundwater quantity, quality, and use.

Water Yield (CBM Produced Water)

Table 2–8 shows the modeled quantity of water that would be removed during CBM development occurring from 2002 through 2017. The projected discharge is summarized by sub-watershed. This CBM produced water would be derived primarily from storage within the developed coals and from groundwater contained in sand units leaking into the coals as a result of coal depressurization. Water removal would be projected to peak during 2007, at a rate of 462,400 acre-feet per year. Depending on the water handling practices used within each sub-watershed, an estimated 55 to 68 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection.

Aquifer Characteristics

The removal of water from the coal seam is unlikely to have any measurable effects on the physical characteristics of the aquifer, and its ability to store or transport water. Subsidence is discussed under Geologic Hazards starting on page 4–84.

Aquifer Conditions

The removal of water from the coal seam and the subsequent disposal of the produced water likely would have the following effects on conditions existing within affected aquifers at various times during or after CBM development.

Alluvial Aquifers

Depending on the water handling practices used within each sub-watershed, an estimated 80 to 95 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments. A portion of the released water would recharge the alluvium. Several studies of water flow losses in creeks during dry weather periods have shown that a considerable portion of the discharged water infiltrates the alluvium within a few miles of the surface discharge outfall.

Alluvium with near-surface water tables would likely see increases in water levels from CBM produced water discharges. The increase in water level may be exhibited as standing water in areas not previously displaying this condition or as wetland development.

The City of Gillette currently pumps the alluvium of Donkey Creek within the community to maintain lower water levels. The city’s pumping rate would likely have to increase to maintain current water levels during continued CBM field development.

Fort Union Coal Aquifer

Drawdown

Under Alternative 1, the model-projected composite maximum drawdown from CBM development occurring in the coal-bearing units within the upper portion of the Fort Union Formation would occur during the period 2006 to 2009 depending on location. The modeled composite drawdown for the year 2009 is shown in Figure 4–1 and the modeled composite drawdown for the year 2012, after the last Project wells are drilled, is shown in Figure 4–2. Because coal mining and CBM operations are dynamic, the maximum areal extent of drawdown may change over time and may increase in some areas of the PRB while recovering in others. The maximum drawdowns in any given watershed generally coincide or closely follow the period of peak water production in the watershed (Table 2-8). The CBM water production in the Project Area under Alternative 1 is expected to peak in 2007 (Table 2-8).

The maximum extent of projected drawdown in the target coals, defined as a drawdown of at least ten feet, extends 10 to 12 miles beyond areas of CBM development. Projections of maximum drawdown and extent of drawdown are based on the projected locations of CBM development. Actual drilling locations and density of drilling may result in shifts of drawdown contours from the projections illustrated in Figure 4–1 and Figure 4–2.

Maximum projected drawdowns would occur in the centers of CBM development. Within the northern portion of the Project Area, CBM production would occur from two or more coal-bearing units. Drawdown would depend on the depth of the target coal(s) below the surface. In deep areas of the basin, such as the northwestern portion of the basin, model-projected composite maximum drawdowns would exceed 1,200 feet. In shallow areas of the basin, such as the southeastern portion of the basin, modeled drawdowns would be 200 to 400 feet over most of the active CBM well fields.

The projected rate of coal aquifer drawdown is presented by a graph of modeled drawdown versus time at selected locations in the model. The locations of calibration monitoring wells are shown on Figure 4–3. A water level drawdown graph for selected monitoring wells in the Project Area is shown in Figure 4–4. The graphs show that the water level changes in the coal aquifer that would be induced by CBM development tend to be fairly rapid.

Initial hydraulic head in the coal, as measured by the water level in a well completed in the coal, may be several hundred feet above the top of the coal. This is particularly true in the deep portions of the PRB where the depth to the coal may be over 1,300 feet. Removal of water from the coal in these areas during CBM development could result in drawdown of the hydraulic head to the top of the coal at the location of the pumping wells. For reference, where the depth to the coal is 1,200 feet and the depth to water in a well tapping the coal is 400 feet, an initial hydraulic head of 800 feet would exist. Even though the thickness of the coal itself may only be 100 feet, maximum drawdown in this example could be as much as 800 feet.

Recovery

Recovery of water levels in the coal would become apparent after water production started to decline. Water production is expected to start declining about 2008 and end about 2018. Recharge to the coal comes primarily from the redistribution of stored water in the surrounding coal and continued slow leakage from overlying Wasatch sand aquifers and underlying Fort Union Formation sand aquifers. By 2030, water levels in the coal are projected to recover to within 55 to 65 feet (75 to 80 percent) of pre-operation levels. The maximum extent of the 10-foot drawdown is projected to extend 10 to 12 miles from the limit of CBM development (Figure 4–5).

Initially, recovery would be primarily due to redistribution of groundwater stored in the aquifer. When the stresses of pumping are removed, the groundwater in storage outside the CBM development areas would resaturate and repressurize the areas that were partially depressurized during operations. The amount of groundwater storage within the coal and within the sand units above and below the coal is enormous, and redistribution would be projected to result in a fairly rapid initial recovery of water levels in the coal. The model projects that this initial recovery period would occur over 14 to 16 years, with water levels recovering to within 55 to 65 feet (75 to 80 percent) of pre-operational conditions within this period.

Complete water level recovery would be a very long-term process because actual recharge to the coal aquifer would need to replace groundwater removed from storage during CBM operations. Most of this recharge would come from leakage from overlying and underlying sand and undeveloped coal units. These units would be, in turn, recharged from surface infiltration. Recharge rates would increase temporarily as a result of infiltration of CBM water discharged to impoundments and streams. However, based on modeling and information from nested wells, it would take tens of years before these surface recharge influences would appear in the coal. Recharge to the coal in the central part of the PRB through surface infiltration at the outcrop areas would take even longer. Coal mining along the eastern and northwestern subcrop would result in minimal recharge to the coal while the mines are active, due to the groundwater sink caused by pit dewatering. As mines are reclaimed and eventually shut down, the backfilled areas would become long-term recharge zones for the coal aquifer. Infiltration through backfill areas may be very significant because the permeability of the backfill materials tends to be much higher than in the original unmined materials. In addition, most of the creeks would be diverted over these backfilled areas, providing an important source of recharge water.

The projected recovery of water levels following the cessation of CBM development and coal mining operations is illustrated in Figure 4–5 for selected locations in the model. The graphs show water levels recovering to within 55 to 60 feet (75 to 80 percent) of pre-operational conditions within 14 to 16 years following cessation of CBM operations. However, the rate of recovery would slow dramatically after this initial recovery period, eventually recovering to within less than 20 feet (95 percent) of pre-operational conditions over the next hundred years or so.

Figure 4–1 Modeled Composite Drawdown in Upper Fort Union Coals – Year 2009

Figure 4–2 Modeled Composite Drawdown in Upper Fort Union Coals – Year 2012

Figure 4–3 Location of Calibration Monitoring Wells

Figure 4–4 Modeled Water Level vs. Time for Selected Monitoring Locations

Wasatch Sand Aquifer

Drawdown

Drawdown effects in the overlying Wasatch sand aquifers are projected to be much less than in the coal aquifer, but may be noticeable for deep sand units that occur within 50 feet of a developed coal. Drawdowns in deep sands would be in the range of 10 to 250 feet in most areas. Drawdowns in the deep sand would tend to occur several years after drawdown in the coal occurs.

Drawdown in the shallow Wasatch sands would be much less than in the deep Wasatch sands and would range from 10 to 100 feet in most areas. Drawdown in the shallow Wasatch sands would be greatest near mines and areas where the target coal seam(s) for CBM development are nearer the surface. However, in some areas of the basin, the water levels in shallow Wasatch sands would increase due to infiltration of CBM produced water. Based on the detailed model completed for the LX Bar sub-watershed, water levels in the shallow Wasatch sands would tend to increase slowly, with a projected increase of approximately ten feet, due to enhanced recharge from surface discharge of CBM produced water to creeks and ponds (AHA 2001b).

Model projections in the Wasatch sands are less reliable than in the coal because of the discontinuous nature of the sands. A detailed evaluation of the Caballo Creek area was performed because this area has a long history of CBM development and also has long-term monitoring data from Wasatch sands close to the developed coal seams. A more detailed sub-area model was constructed for this area. The extensive monitoring data in this area allowed a more definitive calibration of the sub-model, and accordingly, the projections from the sub-model are likely to be more reliable. Figure 4–4 shows the drawdown vs. time projected in the deeper Wasatch sands of the Caballo Creek area, approximately 40 to 50 feet above the developed coal, for some selected monitoring well locations.

The regional model projects the effects on Wasatch sands in a more general way. The deep Wasatch sands in the regional model are represented by layers that are situated between 50 to 150 feet above the top of the highest developed coals. Due to the greater separation from the coals, these sands would not be affected to the extent that is seen in the Caballo Creek area. Figure 4–6 shows the projected drawdowns in the deep Wasatch sands during 2012 when CBM drilling is projected to cease. Figure 4–7 shows projected drawdowns in the deep Wasatch sands during 2018 when CBM water production is projected to cease. Maximum drawdowns in the deep Wasatch sands would occur in the centers of CBM development where there is the most available head in the coal. Larger heads in the coals would lead to greater drawdowns, which, in turn, would increase the vertical hydraulic gradient from the overburden to the coal. Drawdown in the Wasatch sands would be limited to the areas of active CBM development. The model indicates that drawdown in the Wasatch Formation associated with CBM development tends to lag several years behind drawdown occurring in the underlying coal in any given area. This is consistent with observed water level changes in well-developed CBM production areas such as the Caballo Creek area (Figure 4–4).

Figure 4–5 Modeled Water Level Recovery in Upper Fort Union Coals – Year 2030

Figure 4–6 Modeled Water Level Change for Deep Wasatch Sand – Year 2012

Figure 4–7 Modeled Water Level Change for Deep Wasatch Sand – Year 2018

The drawdown in the Wasatch sands would continue after CBM operations cease and coal water levels start to recover, because the Wasatch Formation is a source of recharge to the coal. There likely would be localized areas in the Wasatch sands that would see greater drawdowns than projected by the model, due to conducive faults, poorly grouted well bores, and exploration borings.

Recharge

Some of the groundwater released to surface drainages or impoundments would recharge shallow bedrock (Wasatch Formation). A portion of the released water would recharge the alluvium. In turn, the alluvium along many of the creek valleys would recharge the underlying Wasatch sands. Several studies of water flow losses in creeks during dry weather periods have shown that a considerable portion of the discharged water infiltrates the alluvium within a few miles of the surface discharge outfall. Bedrock monitoring wells located close to areas where CBM produced water is discharging into creeks or impoundments have shown water level increases, indicating that this recharge is occurring. The nature of recharge in any area is directly related to the permeability of the surface exposures of the Wasatch Formation occurring under creeks and ponds.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was obtained from the model output for each of the affected sub-watersheds (Table 2-8). This projected water production would be managed according to the water handling options identified for each sub-watershed under Alternative 1 (Table 2-9). The projected net recharge is calculated based on the percentage of the produced water handled by each method and the projected loss due to infiltration.

The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate for the area, in inches per year. This additional recharge was then input into the model for the area of CBM development within each watershed during the time period when CBM operations are expected to be active.

The projected water level change in shallow Wasatch sands during 2005 and 2012 is shown in Figure 4–8 and Table 4–9. Water levels in the shallow sands are projected to rise initially in some areas during CBM development due to the modeled recharge of CBM produced water, before being drawn down.

Recovery

Recovery in the deep Wasatch sands would tend to occur once coal water levels recovered substantially and induced leakage from the deep Wasatch sands into the coal became minimal. The model projects that water levels in the areas of highest drawdown would recover within 30 to 35 feet (50 to 70 percent) of pre-operational conditions within 15 to 17 years following cessation of CBM operations. Water levels would eventually recover to within less than 20 feet (80 percent) of pre-operational conditions over the next hundred years or so (Figure 4–10).

The projected recovery of water levels in the deep Wasatch sands following the cessation of CBM development would be slow until coal water levels recover, because the sands would continue to recharge the coal even after CBM development ceases. Complete recovery to pre-operational conditions may take many years.

Projected recovery of water levels in the shallow Wasatch sands is shown in Figure 4–11 for the year 2030. Complete recovery to pre-operational conditions may take many years.

Groundwater Use

Water Wells

Impacts to individual water wells completed within the coal, and in sands above the coal, would depend on proximity to CBM production wells, depth and completion interval of the water well, and the water well yield required to maintain it as a usable source. Drawdown of water levels in coal aquifers caused by CBM development potentially may impact individual well users by reducing well yield. Refer also to ’Methane Emissions’ discussion presented below.

Under Alternative 1, the model projects over 1,200 feet of coal aquifer drawdown near the centers of active CBM development, with drawdown in excess of 10 feet extending some 10 to 12 miles from these areas (Figure 4–1). The maximum available drawdown (the hydraulic pressure head) in the coal aquifer in the affected areas ranges from 300 to 1,400 feet. Most individual water supply wells in the coal seam do not exceed 600 feet and have up to 300 feet of available drawdown. Well pumps typically are set between 50 to 200 feet below the static water level in the well. Significant impact in terms of well yield or availability is likely to be an issue only if the drawdown exceeds approximately 20 to 30 percent of available drawdown at any given location. This area would tend to coincide with the area of drawdown in excess of approximately 100 feet. The decreased head against which the well pump has to operate may cause the pump discharge to decrease. However, if sufficient available drawdown remains in the well, yield may be restored by installing a larger pump. In cases where the drawdown causes the water level in a well to drop below the intake of the pump, the pump may have to be lowered in the well. Even where yield is restored, the well may be too gassy to pump or use.

Water level changes in wells are not expected to be as significant in the aquifers above or below the coal because the coal is confined both above and below by low permeability claystone layers over most of the PRB. Examination of drilling and geophysical logs from CBM wells shows that the coal seams are separated from sands in the overlying Wasatch Formation by relatively continuous, low-permeability claystone and siltstone confining layer that ranges in thickness from 11 to 363 feet. In most cases, the claystone confining unit is at least 30 feet thick. The large variation in thickness is mostly a function of whether any significant sands exist in the lower part of the Wasatch Formation at a given location. This claystone unit restricts hydraulic communication between the coal and the overlying Wasatch sands. A significant period of time (typically several years) will likely pass before drawdown effects due to pumping groundwater from the

Figure 4–8 Modeled Water Level Change for Shallow Wasatch Sand – Year 2005

Figure 4–9 Modeled Water Level Change for Shallow Wasatch Sand – Year 2012

Figure 4–10 Modeled Water Level Recovery in Deep Wasatch Sand – Year 2030

Figure 4–11 Modeled Water level Recovery in Shallow Wasatch Sand – Year 2030

coal are apparent in the overlying Wasatch sands. Although, as noted in Chapter 3, the integrity of the confining layer may be compromised locally by water supply wells screened through both the coal and the overlying sands, by deteriorating well casings, or by poorly plugged oil and gas wells or exploratory drill holes, isolated local influences do not affect regional results.

Projected drawdown in the Wasatch sands may affect users of Wasatch aquifer water. The water well agreement would provide sufficient protection to landowners if impacts were to occur on federal mineral ownership lands and non-federal lands for which the agreement is in place.

The model also indicates that the sand units within the lower members of the Fort Union Formation may experience water levels declines of up to 50 feet where intensive CBM production occurs in the overlying Fort Union Formation coals. This is unlikely to noticeably affect the utilization of these aquifer units for water supply. For individually impacted water wells, refer to the "Mitigation Measures" section. A standard agreement has been developed by CBM operators to monitor and mitigate impacts to individual water well owners that are caused by CBM operations. A copy of this water well agreement format is contained in Appendix G. Wyoming Statute 41-3-933 specifically states that groundwater levels and artesian pressures in water wells are not guaranteed.

Artesian flow has been reported in wells located near the Powder River, where the hydraulic head from the deep coal aquifer extends to the surface. Groundwater has been discharging in this area, in part to artesian wells. A reduction in hydraulic head within the coal aquifer (projected to occur during CBM development under Alternative 1) likely would reduce or eliminate artesian flow in water wells. Artesian flow in wells likely would not recover until hydraulic head in the coal aquifer recovers sufficiently following CBM development.

Methane Emission

Withdrawal of water from the coal aquifer during CBM development can depressurize the coal aquifer and induce methane release into nearby water wells completed in the coal aquifer. Individual coal aquifer well users may experience increased methane emissions if their wells fall within an area experiencing noticeable aquifer depressurization.

Records of first indications of methane production in monitoring wells that have experienced water level drops due to mining indicate that methane emission from the coal can occur with as little as 50 feet of head drop (Belle Ayr Mine groundwater monitoring data). Consequently, coal wells within the predicted 50-foot drawdown area may be susceptible to this impact. Methane emissions by a well pose a potential explosive safety hazard, particularly if gases can build up in an enclosed space. In areas within two miles of operational CBM well fields, well houses and basements should be well ventilated and periodically checked for methane gas.

Groundwater Quality

Groundwater quality within the regional aquifer systems of the PRB would not be noticeably affected under Alternative 1. Any noticeable effects on groundwater quality would be expressed as effects on aquifers that would be recharged during CBM development or existing springs (which emanate from the ground and may contain groundwater derived from these aquifers).

Water Wells

Where CBM wells are drilled in close proximity to existing water wells, immediately after the drilling and completion of the CBM wells, water quality in existing water wells may be temporarily affected. The WSEO has received reports of increased sediment, fines, and water odor appearing in wells where water is being produced from a zone shallower than the target coal. These effects were reported to be temporary, clearing up after a period of time.

Aquifers

Effects on groundwater quality within the Quaternary alluvial aquifers could occur, unless the quality of CBM produced water discharging to surface drainages or infiltrating alluvial aquifers is strictly controlled. CBM produced water is typically slightly alkaline, hard sodium bicarbonate or sodium sulfate type water that may be enriched in some constituents such as iron, manganese, or barium. Surface waters occurring at lower elevations in the PRB typically are hard, alkaline sodium sulfate-type waters (Chapter 3). NPDES permits, required for the surface discharge of produced water, limit concentrations of produced water constituents of concern to levels that would not cause degradation of surface water quality or alluvial aquifer quality.

The effects of CBM produced water on alluvial aquifers in the Middle Powder River sub-watershed would need to be analyzed site-specifically by BLM at the APD/POD level of analysis to ensure alluvial aquifer quality would not be degraded by CBM development activities. The Middle Powder River sub-watershed is the only portion of the Project Area where documentation exists (Chapter 3) that TDS levels in CBM produced water (2,977 mg/L), on average, noticeably exceed TDS levels in natural stream flows (1,550 mg/L).

Very little effect on groundwater quality within Lower Tertiary aquifer systems of the PRB would be expected under Alternative 1. The quality of the water infiltrating the surface during CBM development, and recharging the Wasatch and Fort Union aquifers would not be expected to be lower than the existing groundwater within these aquifers. Water quality in the Wasatch aquifer is quite variable (Chapter 3) and would be unlikely to be noticeably affected by CBM development. Since CBM produced water recharging the Fort Union coal aquifer was produced from this same aquifer, water quality in the Fort Union aquifer also would be unlikely to be noticeably affected by CBM development. No contaminants would infiltrate the surface or reach these aquifers.

Existing Springs

The sources and existing natural quality of spring waters have not been studied throughout the Project Area. However, spring water chemistry likely would be similar to the characteristics of a spring's source aquifer, shallow infiltrated water, or surface water. Under Alternative 1, CBM produced water could be mixed with shallow infiltrated water or surface water from natural sources.

The coal aquifer, which yields CBM produced water, also is the source aquifer for some springs in the Project Area. Contributions of CBM produced water to spring flows emanating from the coal aquifer are not likely to degrade the spring water quality, since characteristics and constituent concentrations would be similar.

Infiltration of CBM produced water mixed with natural stream flows, and subsequent discharge of these waters at springs, likely would not have noticeable effects on the quality of spring water. Springs having water chemistry similar to surface waters likely would not have noticeable effects on water quality under Alternative 1. The effects of CBM produced water on springs in the Middle Powder River sub-watershed would need to be analyzed site-specifically to ensure spring water quality would not be degraded by CBM development activities.

CBM operations are not expected to have any impact on the water quality of Moyer Springs because discharge water is not likely to encroach on the recharge area of the spring. Water from Moyer Springs is of calcium sulfate chemical type, with total dissolved solids concentrations in the 1,000 mg/l to 2,000 mg/l range (Hodson et al. 1973). CBM produced water likely would be of equal or better quality. Therefore, even if some CBM discharge water did recharge Moyer Springs, CBM operations should not adversely affect its water quality.

Groundwater Flow Systems

The groundwater resources of the PRB are vast, and regional flow within and out of the PRB would not be noticeably affected under Alternative 1. Any noticeable effects on local groundwater flow systems would be expressed as effects on existing springs or groundwater discharge areas.

Existing Springs

The public has expressed concern regarding the potential effects of CBM development on springs issuing from clinker outcrops, such as the Moyer Springs located north of Gillette in Sec. 30 T.51N. R.71W. Moyer Springs is located at the base of an exposed clinker deposit in the outcrop area of the Roland-Smith coal seam. Recharge of the springs is through surface infiltration and lateral movement of water from adjacent clinker and alluvium. The springs issue along a low-permeability zone at the contact between the clinker and the coal. Large areas of clinker are exposed northeast and southeast of Moyer Springs (Williams 1978). This exposure allows a large amount of recharge to the clinker by infiltration of rainfall and snowmelt. Hodson et al. (1973) reported a flow of 200 gallons per minute from Moyer Springs.

No decrease in spring flows would be anticipated under Alternative 1 where the issuance of springs results from flow along a near-surface zone of low permeability intercepting the surface. Many springs in the Project Area, including Moyer Springs, represent this type of occurrence. A contact having low permeability inhibits flow between the clinker and the coal. The presence of a low-permeability zone between the clinker and the coal results in water in the clinker being channeled to the spring rather than recharging the coal. A decrease in recharge to the spring (not projected to occur under Alternative 1) could cause a reduction in flow for this type of spring.

The natural discharge of springs in the Project Area potentially could be affected by a reduction in the hydraulic head in an aquifer unit, if the aquifer experiencing the reduction in hydraulic head were the spring's source aquifer. Spring flow could decrease or stop under these conditions. Spring flow likely would not recover until the hydraulic head in the coal aquifer recovers sufficiently following CBM development. Springs issuing from the Wasatch sands into surface drainages may experience increased flows during the time period that CBM produced water is recharging shallow aquifers.

The use of infiltration impoundments or flow-through stock reservoirs during surface discharge associated with CBM development could increase existing spring flows where a near-surface zone of low permeability intercepts the surface, unless these water handling facilities are sited to minimize this potential effect. Avoidance of sites where a zone of low permeability intercepts the surface downhill or downgradient from an area where considerable infiltration of CBM produced water is occurring, would minimize the potential for shallow infiltrated water to increase the recharge or spring flow of existing springs.

Only minimal infiltration would be anticipated where containment ponds or reservoirs constructed in upland areas would be used to handle CBM produced water. It is unlikely that existing spring flows would be affected near properly engineered and constructed containment impoundments.

Groundwater Discharge Areas

Groundwater has been discharging to the surface in many areas near the Powder River, where the hydraulic head from the deep coal aquifer intercepts the surface, and flow along the natural groundwater gradient is toward the river. A reduction in hydraulic head within the coal aquifer, projected to occur during CBM development under Alternative 1, likely would reduce groundwater discharge and base flows in surface drainages within the Powder River's drainage basin. Groundwater discharge likely would not recover until the hydraulic head in the coal aquifer recovers sufficiently following CBM development. The discharge of CBM produced water to surface drainages that feed into the Powder River would mitigate this projected reduction in natural groundwater discharge. The effects of surface discharge of CBM produced water to the Powder River's drainage basin would need to be analyzed site-specifically by BLM at the APD/POD level of analysis to ensure that appropriate water balance and quality would be maintained during CBM development activities.

Only minimal infiltration would be anticipated where containment ponds or reservoirs constructed in upland areas would be used to handle CBM produced water. It is unlikely that new springs would develop or shallow infiltrated water would resurface near properly engineered and constructed containment impoundments.

The use of infiltration impoundments or flow-through stock reservoirs during surface discharge associated with CBM development could cause new springs to develop where a near-surface zone of low permeability intercepts the surface, unless these water handling facilities are sited to minimize this potential effect. Avoidance of sites where a zone of low permeability intercepts the surface downhill or downgradient from an area where considerable infiltration of CBM produced water is occurring, would minimize the potential for shallow infiltrated water to resurface.

One detailed model study performed for the LX Bar drainage (AHA 2001d) showed that the potential contributions to surface flows from increased groundwater discharge would be much less than one cfs, if all CBM produced water in the LX Bar drainage were held in infiltration impoundments. However, the same detailed model study also showed that the potential rise in shallow groundwater level would be up to ten feet near impoundments, if all CBM produced water in the LX Bar drainage were held in infiltration impoundments.

In many areas where infiltration impoundments could be constructed, the current water table may be less than ten feet below the surface. In these areas the increase in water level may be exhibited as groundwater discharge to the surface, standing water in areas not previously displaying this condition, or as wetland development, unless the percentage of CBM wells having produced water held in infiltration impoundments is carefully controlled. The effects of impoundment and infiltration of CBM produced water would need to be analyzed site-specifically to ensure that water table and groundwater discharge effects are carefully balanced or mitigated during CBM development activities.

Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences in recharge that would occur based on differences in water handling options, (discussed below), the effects on groundwater resources would be similar to those described under Alternative 1.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was obtained from the model output for each of the affected sub-watersheds (Table 2-8). This modeled water production would be managed according to the water handling options identified for each sub-watershed under Alternative 2A (Table 2-21). The net recharge is calculated based on the percentage of the produced water handled by each method and the projected conveyance loss. The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate for the area, in inches per year. Depending on the water handling practices used within each sub-watershed, under Alternative 2A an estimated 55 to 66 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection. This recharge under Alternative 2A is compared below to the values input into the model under Alternative 1.

Alternative 2A involves different handling of the water produced by CBM operations in certain sub-watersheds. Depending on the water handling practices used within each sub-watershed, an estimated 70 to 85 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments. The proportion of water handled by infiltration impoundment would be emphasized under Alternative 2A. Under Alternative 2A, less CBM produced water would be discharged to surface drainages than under Alternative 1. More CBM produced water would be handled using infiltration impoundments, containment impoundments, land application disposal (LAD), and injection than under Alternative 1. Also, under Alternative 2A, there would be a five percent reduction from Alternative 1 in the produced water handled using LAD in the Crazy Woman Creek sub-watershed, with a corresponding increase in the produced water handled by injection. In the Salt Creek sub-watershed, surface discharge and some LAD would be replaced by increased use of infiltration or containment impoundments, and injection as preferred water-handling methods.

The change in water handling methods would result in a decrease in infiltration compared to Alternative 1. This decrease would be small, six percent or less, on average, in all sub-watersheds except Salt Creek, where 19 percent less water would infiltrate at the ground surface than under Alternative 1. The projected reduction in surface infiltration, on average, would represent a small fraction of an inch per year in any sub-watershed. This slight change would have a negligible effect on groundwater conditions within the affected drainages. The Crazy Woman Creek and Salt Creek sub-watersheds would have an increased percentage of water management by injection into deeper aquifers (below the coal zone).

Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences in recharge that would occur based on differences in water handling options, (discussed below), the effects on groundwater resources would be similar to those described under Alternative 1.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was obtained from the model output for each of the affected sub-watersheds (Table 2-8). This modeled water production would be managed according to the water handling options identified for each sub-watershed under Alternative 2B (Table 2-22). The net recharge is calculated based on the percentage of the produced water handled by each method and the projected conveyance loss. The calculated net recharge volume, on a year-by-year basis, was divided by the projected CBM development area within each sub-watershed to obtain an equivalent recharge rate for the area, in inches per year. Depending on the water handling practices used within each sub-watershed, under Alternative 2B an estimated 56 to 66 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection. This recharge under Alternative 2B is compared below to the values input into the model under Alternative 1.

Alternative 2B involves different handling of the water produced by CBM operations in certain sub-watersheds. Depending on the water handling practices used within each sub-watershed, an estimated 70 to 85 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments. The proportion of water handled by infiltration impoundment would be emphasized, but would have an upper limit under Alternative 2B, and active treatment for CBM produced water by reverse osmosis or other suitable methods would be included as a water handling method. Under Alternative 2B, less CBM produced water would be discharged to surface drainages than under Alternative 1. More CBM produced water would be handled using infiltration impoundments, containment impoundments, land application disposal (LAD), and injection than under Alternative 1. Also, under Alternative 2B, there would be a five percent reduction from Alternative 1 in the produced water handled using LAD in the Crazy Woman Creek sub-watershed, with a corresponding increase in the produced water handled by injection. In the Salt Creek sub-watershed, surface discharge and some LAD would be replaced by increased use of infiltration or containment impoundments, and injection as preferred water-handling methods.

The change in water handling methods would result in a decrease in infiltration at the ground surface. This decrease would be small, six percent or less, on average, in all sub-watersheds except Salt Creek, where 19 percent less water would infiltrate at the ground surface than under Alternative 1. The projected reduction in surface infiltration, on average, would represent a small fraction of an inch per year in any sub-watershed. This slight change would have a negligible effect on groundwater conditions within the affected drainages. The Crazy Woman Creek and Salt Creek sub-watersheds would have an increased percentage of water management by injection into deeper aquifers (below the coal zone).

Alternative 3

Alternative 3 (No Action) assumes that no new Federal CBM wells would be completed, except for potential drainage situations. This would result in a substantial reduction in projected new CBM wells, from 39,367 to 15,458. Except for the differences discussed below, the effects on groundwater resources would be similar to those described under Alternative 1.

Under Alternative 1, the largest numbers of new Federal CBM wells would be drilled in the Upper Powder River and Upper Belle Fourche River sub-watersheds (24,898 of 39,367 projected wells under Alternative 1). The exclusion of federal wells from these sub-watersheds under Alternative 3 represents a 77 percent reduction in the Upper Powder River sub-watershed (14,531 wells) and a 43 percent reduction in the Upper Belle Fourche River sub-watershed (2,531 wells). The percentage reduction in wells also would be great in the Middle Powder River sub-watershed, where the reduction would be 79 percent (or 757 wells). Over 1,000 wells also would be eliminated in each of the following sub-watersheds: Crazy Woman Creek (1,986 wells); Clear Creek (1,265 wells); Little Powder River (1,076 wells); and Antelope Creek (1,041 wells). Relatively lower percentage reductions in wells would occur in the Upper Tongue River sub-watershed (17 percent) and in the Clear Creek sub-watershed (34 percent).

Although water production would decline substantially in all sub-watersheds under Alternative 3, the percentage reduction in water production, compared with Alternative 1, would be less than the reduction in wells shown in Chapter 2. Under Alternative 3, individual wells would have to produce more water to maintain sufficient drawdown and allow methane to be produced.

Water-handling options would be same as under Alternative 1. Depending on the water-handling practices used within each sub-watershed, an estimated 80 to 95 percent of the groundwater produced from CBM operations would be released to surface drainages or impoundments.

The recharge effect was evaluated in this analysis by examining the area of affected alluvial drainages and the probable range of vertical infiltration rates into the Wasatch Formation below the creeks and ponds. The total discharge from CBM operations was projected for each of the affected sub-watersheds (Table 2-32). This projected water production would be managed according to the water-handling options identified for each sub-watershed under Alternative 1 (Table 2-9). The projected net recharge is calculated based on the percentage of the produced water handled by each method and the projected conveyance loss. Depending on the water handling practices used within each sub-watershed, under Alternative 3 an estimated 55 to 68 percent of the pumped water would be recharged to the groundwater system as a result of infiltration along creeks and below impoundments, or direct injection.

The extent of drawdown in the coal units would change, compared to Alternative 1. The greatest change would occur in the sub-watersheds with the largest percentages of Federal wells. The areal extent of the 10-foot drawdown contour would tend to decrease in the vicinity of large concentrations of Federal wells that were projected to be drilled under Alternative 1, for example in the Upper Powder River sub-watershed. It is less likely that State and Fee wells would be developed around the large Federal blocks unless there would be enough wells to maintain adequate drawdown and produce methane.

With the decline in water production, the total quantity of produced water that recharges the shallow bedrock and alluvium would diminish proportionately. The areal extent of recharge would be reduced the most in the Upper Powder River, Upper Belle Fourche River, and Crazy Woman Creek sub-watersheds because these areas would have featured the largest numbers of new Federal CBM wells. The projected changes in water levels in the shallow Wasatch sands would be less that those projected under Alternative 1, in approximate proportion to the difference in water production and consequent recharge.

Under Alternative 3, the change in water levels within the deep Wasatch sands, compared with Alternative 1, would be noticeable in fewer areas. In areas that would have had a high concentration of federal wells under Alternative 1, the extent of drawdown in the coals could be considerably less due to non-development, resulting in less drawdown in overlying sands. However, the regional effect on deep Wasatch sands would be relatively minor, due to the sands' isolation from the pumped coals, making the differences in projected impacts between Alternatives 1 and 3 less apparent. The effects on shallow Wasatch sands would be similar to the effects on deep Wasatch sands.

Cumulative Effects

Regionally, the different PRB coal zones merge, split, and pinch out laterally in complex patterns (Flores 1999, Flores et al. 1999). Coal zone aquifers within the Project Area occur as layers that, individually, are continuous only over an average distance of ten miles or so. While regional groundwater flow toward the north does occur, this flow is interrupted where coal aquifers are discontinuous, and groundwater is discharged in local flow systems. Where coal aquifers are discontinuous, flow in local groundwater systems (bedrock, alluvial, and clinker) appears to dominate over the flow in a regional system (Rankl and Lowry 1990). Most of this local groundwater discharge from bedrock aquifers occurs above stream level and is lost due to evapotranspiration or consumed as soil moisture, and does not make a very noticeable contribution to surface drainages.

The areal extent and magnitude of drawdown effects on coal zone aquifers and overlying or underlying sand units in the Wasatch Formation also would be limited by the discontinuous nature of the different coal zones within the Fort Union Formation and sandstone layers within the Wasatch Formation. Where a coal zone aquifer or sandstone layer pinches out laterally, drawdown effects also would be interrupted somewhat, although leakage from nearby layers would continue to occur. This discontinuous nature of the different coal zones would tend to limit the areal extent of drawdowns occurring in Montana, outside the Project Area, that are associated with CBM development in the PRB within Wyoming.

Computer modeling of groundwater resources could not capture the level of subsurface detail actually existing in the PRB. In order to develop a reasonable model for this analysis, hydrogeologic layers included in the model assumed coal beds are more continuous and have more uniform thicknesses than those actually occurring in the PRB. The drawdown effects on coal zone aquifers and sandstone layers predicted by the model represent the maximum areal extent and magnitude of drawdowns, assuming continuous layers of uniform thickness. Drawdowns in discontinuous layers likely would be limited by the continuous areal extent of the layer. Where coal aquifers are being mined, such as in the coal area near the State line, the mine area is established as a drain node in the model. A quantitative estimate of CBM-associated drawdown near a mine area is difficult to predict.

Alternative 1

The cumulative impacts on groundwater resources from activities associated with CBM development and those impacts associated with coal mining have been included in the groundwater model and impact analysis described earlier in this chapter under Groundwater. Reasonably foreseeable groundwater conditions could not be considered separately for proposed CBM development. Therefore, the analysis included the impacts of existing and reasonably foreseeable CBM development and mining. Reasonably foreseeable coal mining activities, as depicted in mine plans, and existing coal mine effects on groundwater resources were incorporated within the groundwater model. Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-8 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 1.

Northeast of Sheridan, Wyoming the model projects some effects of the proposed Project extending into Montana for a short distance, however these projections near the Montana-Wyoming State line are based on very limited data. Drawdowns of approximately 100 feet in the Fort Union coal zone are projected to extend one to three miles into Montana The model projects coal zone recovery to a 25 foot drawdown by 2030 for most areas in Montana affected by the Project. In the same area, the model projects a ten foot drawdown in the deep Wasatch sands extending approximately 10 miles into Montana, and a 50 foot drawdown extending approximately three miles into Montana. The model projects deep Wasatch sand recovery to a 10-foot drawdown by 2030. The model projects a 10-foot drawdown for shallow Wasatch sands extending approximately six miles into Montana, and a 10-foot buildup in shallow Wasatch sands for a small area extending approximately two miles into Montana. A 50-foot drawdown within the shallow Wasatch sands is projected to extend two to three miles into Montana in a small area. The model projects shallow Wasatch sand recovery to a ten-foot drawdown for most affected areas in Montana by 2030.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 55 to 68 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coals. Pressure redistribution within the coals following termination of water production would cause hydraulic pressure head to recover within approximately 65 feet or less of pre-project levels, within approximately 15 years after the project ends. Complete recovery of water levels likely would take many years. This reduction in hydraulic pressure head likely would cause a slight reduction in regional groundwater discharge to surface drainages within the Powder River drainage system, including drainages downstream of the Project Area, in Montana. However, there would be a corresponding slight increase in surface flows downstream of the Project Area resulting from CBM surface discharges and groundwater discharges to surface drainages from shallow aquifers.

Wasatch aquifers overlying the coals also would be affected by development activities. As the coal is de-pressurized by water removal during mining or CBM development, water contained in deep Wasatch sands would leak into the coals. Water levels in the deep Wasatch sands would be lowered, but not as much or as quickly as the drawdown that would occur in the coal. Water levels in the deep Wasatch sands also would recover following development. Recovery to within approximately 35 feet of pre-operational levels would occur in approximately 17 years. Complete recovery of water levels likely would take many years. Water levels (i.e., the water table) in shallow Wasatch sands also would be lowered during development activities and also would recover after water production ends. In some areas, water levels in very shallow Wasatch sands likely would rise initially, up to 10 feet; before being drawn down due to enhanced recharge from infiltration of CBM produced water.

Differentiation of impacts between CBM development activities and coal development activities is presented below. There are some similarities and some differences in the impacts associated with mining and CBM development.

Effects on the Coal Aquifer

Both mining and CBM development result in partial removal of the water from the coal seam. In mining, the coal is removed so that impacts to the coal aquifer in the areas of mining are considerable. Immediately adjacent to active mine pit areas, the water from the coal aquifer will drain into the pit and become dewatered. The extent of coal aquifer dewatering and de-pressurization associated with mining is largely dependent on the continuity of the coal in the vicinity of the mine and its overall permeability (a function of fracturing). In areas of high coal permeability, which tend to coincide with major fracture trends, the extent of drawdown may be several miles. Areas of limited coal drawdown related to mining are associated with lower permeability or less fracturing in the coal.

During active CBM development, pumping groundwater from the coal induces depressurization. Pumping removes water (and methane) from the coal but leaves the coal itself essentially undisturbed. Depressurization within the coal caused by CBM development will be more widespread than that due to mining because CBM development will cover a much larger area than mining. Mining is limited to an area within two to three miles of the coal outcrop because of overburden-coal strip ratios. CBM development is projected to cover most of the Project Area.

Impacts to Aquifers Stratigraphically Above the Coal

The sand aquifers of the Wasatch Formation are hydrologically separated from the coal zone within the Fort Union Formation by low permeability claystones. During mining, the shallower aquifers (the overburden) must be removed to access the coal. Impacts to these aquifers in mined areas are considerable. Immediately adjacent to active mine pit areas, the Wasatch sands intercepted by excavations may drain into the pit and become dewatered. The areal extent of Wasatch aquifer dewatering associated with mining is largely dependent on the continuity of the sand units occurring near the mine, and whether these sand units are intercepted by mining activities. There are many examples of overburden monitoring wells, completed in relatively isolated sand units, showing very little influence from nearby mining. Drawdown in the coal aquifer, induced by mining, in turn, induces vertical leakage from the overlying Wasatch sands, contributing to drawdown in these sands.

During CBM development, the Wasatch sand aquifers would not be directly impacted by excavations or surface disturbing activities. Leakage from the Wasatch sands into the coal would be enhanced by CBM development. Due to limited hydraulic communication between the coal and the overlying Wasatch sands, a considerable period of time (typically several years) may pass before noticeable drawdown of the sands occurs. The areal extent of drawdowns in the Wasatch sands resulting from CBM development would be much greater than the drawdown areas in the sands caused by mining.

Changes in Infiltration Rates and Recharge

During mining, the overburden (including Wasatch sand aquifers) and coal aquifers are removed and replaced with backfill material (spoils). Infiltration and recharge through the spoils are likely to be higher than in the original undisturbed materials. During CBM development, the aquifers would remain essentially undisturbed and the infiltration and recharge mechanisms also would be unchanged. Water discharged to the surface from CBM operations would increase recharge to alluvial aquifers and underlying Wasatch sands.

Changes in Groundwater Quality

After mining, the coal and Wasatch sand aquifers are replaced with mine spoils having the potential to change the quality of groundwater. During CBM development, water removed from the coal would recharge alluvial and Wasatch sand aquifers, and may cause small changes in groundwater quality.

Discharge of Produced Waters

Both mining and CBM development result in water collection and discharge to surface drainages. Mine inflow water is first stored in sediment ponds to reduce sediment picked up in the pit. Much of this water is used for dust suppression. The discharge water from sediment ponds potentially would have higher TDS values and be of lower quality due to sediment mixing and concentration by evaporation. CBM discharges are essentially sediment-free (as produced from CBM wells), although discharge to surface drainages can increase sediment loading caused by increased stream erosion.

Fort Union Aquifers Underlying the Coal Zone

Mining may affect aquifers underlying the coal zone by potentially influencing recharge water quality. Groundwater withdrawals from lower aquifers for mine use also may affect these aquifers. CBM development may affect lower aquifers by inducing upward leakage from them into the coal during coal depressurization. These cumulative influences were included in the groundwater model.

Moyer Springs

The potential impact to Moyer Springs flows by proposed surface mining has been recognized, as removal of the Wasatch Formation and alluvial overburden during mining operations may decrease recharge to the spring. Accordingly, the Dry Fork Mine Permit requires Dry Fork Coal Company to protect the clinker aquifer that feeds Moyer Springs.

Alternative 2A

The cumulative impacts on groundwater resources would be similar to those described under Alternative 1, except as noted below.

Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-8 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 2A.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 55 to 66 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coal.

Alternative 2B

The cumulative impacts on groundwater resources would be similar to those described under Alternative 1, except as noted below.

Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-8 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 2B.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 56 to 66 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coals.

Alternative 3

The cumulative impacts on groundwater resources would be similar to those described under Alternative 1, except as noted below.

Projected CBM development and CBM development existing or authorized prior to this analysis also were incorporated within the groundwater model. Modeled water production, shown in Table 2-32 and already discussed in this chapter, represented total water production for existing/authorized CBM wells and CBM wells projected under Alternative 3.

Cumulatively, groundwater would be removed from the coal aquifers underlying the Project Area, temporarily reducing or eliminating the hydraulic pressure head in the coal. An estimated 55 to 68 percent of the groundwater removed would infiltrate the surface and recharge the shallow aquifers above the coals.

Surface Water

Surface water resources could be affected by:

- Erosion and degradation of the drainage network;
- Increased sedimentation;
- Surface water quality changes; and
- Changes in suitability for beneficial use

The effects of the project on surface water quantity, quality, and existing uses under Alternative 1, Alternative 2A, Alternative 2B, and Alternative 3 are discussed below.

For the purposes of this analysis, surface water flow is expressed in cfs. The water produced from wells is expressed in gpm. One cfs is equivalent to 448.83 gpm. Large flows or volumes of water are expressed as acre-feet. One acre-foot is equivalent to 43,560 cubic feet, or 325,851 gallons.

Alternative 1

Surface Water Quantity

For analysis purposes, CBM water production modeled in the groundwater impact analysis and shown in Table 2-8 was used to calculate the volume of CBM produced water that would be assimilated under Alternative 1. Each well would have a seven-year life span. Based on model projections of water production for new wells and compilation of water production data for existing wells, the total water production for 39,367 new producing wells and 12,077 existing wells would be approximately 4.4 million acre-feet over the life of the project. The 39,367 new wells would be drilled in the Project Area over a ten-year period, with approximately 5,000 wells being drilled each year for the first six years of the project life. The existing wells include wells already drilled, some of which are producing, and those wells already authorized and projected for completion by 2002, but not necessarily producing. For the purpose of this analysis, it is assumed that all of the 12,077 existing wells have their first year of water production prior to 2002, and that water production for the last of the existing wells to be drilled ends after 2007. Water production from the last of the new wells to be drilled is assumed to conclude in 2017.

Under Alternative 1, CBM produced water flows would be handled through direct discharge to surface drainages, passive treatment prior to surface discharge, discharge to upland and bottomland infiltration impoundments, discharge to containment impoundments, and injection. The projected distribution of water handling methods under Alternative 1 is summarized in Table 2-9. The percentage of water handled by each of these options as a percentage of the total water production is summarized in Table 4–1. The majority of the produced water would be gathered and discharged to the surface, or gathered for discharge into shallow infiltration impoundments. CBM produced water flows discharged to the surface would be distributed to an estimated 4,800 discharge locations, and discharged under the terms of NPDES permits issued by the WDEQ. The discharge at each outfall would average 10 gpm, or approximately 0.02 cfs over the life of the wells producing the water. The maximum discharge at a single outfall, on average, would be approximately 100 gpm, or 0.2 cfs, over the life of the wells producing the water. The maximum flow at each discharge point would represent the average annual runoff from approximately 10 square miles (mi^2) using the 15 acre-feet/mi^2/year described by Lowry et al. (1986).

For the purposes of this analysis, discharge of CBM produced water to surface drainages is assumed to result in a conveyance loss of 80 percent of the total volume of CBM produced water, 82 percent of which would be due to infiltration and 18 percent due to evapotranspiration. These values were derived from studies of surface water losses in creek flows within several drainages of the PRB (Meyer 2000, AHA 2001b). For the purpose of this analysis, the remaining

20 percent of the CBM produced water discharged to surface drainages is assumed to reach the receiving stream at the sub-watershed boundary.

The maximum CBM water volume discharged to the surface annually, prior to conveyance losses, is expected to increase from an estimated 155,000 acre-feet in 2002, to an estimated 222,000 acre-feet, occurring in year 2006. Table 4–4 summarizes the projected annual outflow at each sub-watershed boundary under each Alternative, resulting from surface discharge and accounting for conveyance loss along the stream channels. The projected annual flow of CBM produced water at each sub-watershed boundary would be roughly two percent of the volume of water expected from a 25 year, 24-hour storm event.

Table 4–5 summarizes the projected annual flow of CBM produced water at each sub-watershed boundary as a percentage of the annual stream flow average for each sub-watershed. Under Alternative 1, surface discharge of CBM produced water would account for between 0.02 and 13 percent of the annual average stream flow in each sub-watershed. Increases would be greatest in the Upper Belle Fourche River sub-watershed. Flows attributable to CBM discharges would be greatest during periods of low flow in the receiving streams.

Surface Water Quality

Surface discharge of CBM produced water is authorized by the WDEQ under the terms of a NPDES permit. Each permit specifies effluent limitations established to ensure that numeric water quality criteria contained in Chapter 1 of Wyoming's Water Quality Rules and Regulations for the protection of human health and aquatic life are not exceeded. Constituents of concern for water quality impacts from CBM discharges for which numeric criteria exist include, but are not limited to, arsenic, barium, iron, and manganese. WDEQ recently modified Chapter 1 criterion for these constituents and approved the Barium Antidegradation Policy. New effluent limitations have been established for these constituents which are now basin-specific. Discharges to Class 2 receiving waters will be subject to these effluent limitations and to additional numeric standards contained in Wyoming's Chapter 1 Rules and Regulations. Where effluent limitations cannot be achieved for CBM discharges, treatment of the water may be required. Treatment may be passive, which may include routing the water over a scoria bed to remove constituents such as iron or manganese, or active, which may include ion exchange or reverse osmosis processes for removal of constituents such as barium. With project adherence to NPDES permit requirements, discharges of CBM produced water to surface drainages would not likely result in violations of the Clean Water Act.

Section 20 of Wyoming's Chapter 1 Rules and Regulations incorporates a narrative water quality standard, which specifies that all surface waters with potential for use as an agricultural water supply shall be maintained at a quality which supports the use, and any degradation shall not cause a measurable decrease in crop or livestock production. Federal regulations under 40 CFR 435, Subpart E, also require that discharges of produced water be used for specific agricultural or wildlife uses, and that the produced water should be of acceptable quality to support those uses. Compliance with the federal regulations and documentation of beneficial use of CBM produced waters would be mandated by the WDEQ under the NPDES program.

Table 4–4 Projected Outflow at Sub-Watershed Boundary for Projected CBM Produced Water Discharge

Sub-Watershed	Total Surface Discharge[1] 2002–2017 (acre-feet)	Conveyance Loss[2] (acre-feet)	Projected Outflow at Sub-Watershed Boundary[3] Annual Average for 2002–2017		
			cfs	gpm	acre-feet/yr
Proposed Action					
Upper Tongue River	243,722	194,977	3.96	1,778	2,867
Upper Powder River	1,239,442	991,553	20.14	9,039	14,582
Salt Creek	510	408	0.01	4	6
Crazy Woman Creek	220,821	176,656	3.59	1,610	2,598
Clear Creek	271,395	217,116	4.41	1,979	3,193
Middle Powder River	60,413	48,331	0.98	441	711
Little Powder River	68,009	54,407	1.11	496	800
Antelope Creek	62,619	50,095	1.02	457	737
Upper Cheyenne River	18,786	15,029	0.31	137	221
Upper Belle Fourche River	195,403	156,322	3.18	1,425	2,299
Alternative 2A					
Upper Tongue River	69,635	55,708	1.13	508	819
Upper Powder River	413,147	330,518	6.71	3,013	4,861
Salt Creek	0	0	0.00	0	0
Crazy Woman Creek	31,546	25,237	0.51	230	371
Clear Creek	77,541	62,033	1.26	566	912
Middle Powder River	23,236	18,589	0.38	169	273
Little Powder River	26,157	20,926	0.43	191	308
Antelope Creek	45,541	36,433	0.74	332	536
Upper Cheyenne River	13,663	10,930	0.22	100	161
Upper Belle Fourche River	195,403	156,322	3.18	1,425	2,299
Alternative 2B					
Upper Tongue River	243,722	146,233	2.97	1,333	2,150
Upper Powder River	661,035	449,504	9.13	4,098	6,610
Salt Creek	0	0	0.00	0	0
Crazy Woman Creek	94,637	60,568	1.23	552	891
Clear Creek	232,624	148,879	3.02	1,357	2,189
Middle Powder River	41,825	26,768	0.54	244	394
Little Powder River	47,083	30,133	0.61	275	443
Antelope Creek	56,926	36,433	0.74	332	536
Upper Cheyenne River	17,078	10,930	0.22	100	161
Upper Belle Fourche River	217,114	173,691	3.53	1,583	2,554
Alternative 3					
Upper Tongue River	93,664	74,931	1.52	683	1,102
Upper Powder River	412,862	330,289	6.71	3,011	4,857
Salt Creek	825	660	0.01	6	10
Crazy Woman Creek	96,816	77,453	1.57	706	1,139
Clear Creek	130,591	104,473	2.12	952	1,536
Middle Powder River	10,315	8,252	0.17	75	121
Little Powder River	38,166	30,533	0.62	278	449
Antelope Creek	20,841	16,672	0.34	152	245
Upper Cheyenne River	11,290	9,032	0.18	82	133
Upper Belle Fourche River	93,678	74,943	1.52	683	1,102

Notes:
1. Extracted from Tables 2-8, 2-9, 2–21, 2–22, and 2–32 in Chapter 2
2. Loss due to infiltration plus evapotranspiration along stream channels
3. Calculated as Total Surface Discharge minus Conveyance Loss

Table 4–5 Projected CBM Annual Outflows Compared with Average Annual Stream Flow by Sub-Watershed

Sub-Watershed	Projected Annual Outflow at Sub-Watershed Boundary[1] (cfs)	Average Annual Stream Flow[2] (cfs)	CBM Discharges as a Percent of Average Annual Stream Flow (percent)
Alternative 1			
Upper Tongue River at State Line near Decker, WY	3.96	463	0.9
Upper Powder River at Arvada, WY	20.14	281	7.2
Salt Creek near Sussex, WY	0.01	44.4	0.02
Crazy Woman Creek at Upper Station near Arvada, WY	3.59	56.7	6.3
Clear Creek nr Arvada, WY	4.41	181	2.4
Middle Powder River at Broadus, MT	0.98	465	0.2
Little Powder River above Dry C near Weston, WY	1.11	22.9	4.8
Antelope Creek near Teckla, WY	1.02	12.6	8.1
Upper Cheyenne River near Riverview	0.31	60	0.5
Upper Belle Fourche River below Moorcroft, WY	3.18	24.6	13
Alternative 2A			
Upper Tongue River at State Line near Decker, WY	1.13	463	0.2
Upper Powder River at Arvada, WY	6.71	281	2.4
Salt Creek near Sussex, WY	0.00	44.4	0
Crazy Woman Creek at Upper Station near Arvada, WY	0.51	56.7	0.9
Clear Creek nr Arvada, WY	1.26	181	0.7
Middle Powder River at Broadus, MT	0.38	465	0.08
Little Powder River above Dry C near Weston, WY	0.43	22.9	1.9
Antelope Creek near Teckla, WY	0.74	12.6	5.9
Upper Cheyenne River near Riverview	0.22	60	0.4
Upper Belle Fourche River below Moorcroft, WY	3.18	24.6	13
Alternative 2B			
Upper Tongue River at State Line near Decker, WY	2.97	463	0.6
Upper Powder River at Arvada, WY	9.13	281	3.2
Salt Creek near Sussex, WY	0.00	44.4	0
Crazy Woman Creek at Upper Station near Arvada, WY	1.23	56.7	2.2
Clear Creek nr Arvada, WY	3.02	181	1.7
Middle Powder River at Broadus, MT	0.54	465	0.1
Little Powder River above Dry C near Weston, WY	0.61	22.9	2.7
Antelope Creek near Teckla, WY	0.74	12.6	5.9
Upper Cheyenne River near Riverview	0.22	60	0.4
Upper Belle Fourche River below Moorcroft, WY	3.53	24.6	14
Alternative 3			
Upper Tongue River at State Line near Decker, WY	1.52	463	0.3
Upper Powder River at Arvada, WY	6.71	281	2.4
Salt Creek near Sussex, WY	0.01	44.4	0.02
Crazy Woman Creek at Upper Station near Arvada, WY	1.57	56.7	2.8
Clear Creek nr Arvada, WY	2.12	181	1.2
Middle Powder River at Broadus, MT	0.17	465	0.04
Little Powder River above Dry C near Weston, WY	0.62	22.9	2.7
Antelope Creek near Teckla, WY	0.34	12.6	2.7
Upper Cheyenne River near Riverview	0.18	60	0.3
Upper Belle Fourche River below Moorcroft, WY	1.52	24.6	6.2

Notes:
1 Extracted from Table 4–1.
2 Extracted from Table 3-5.

The quality of the produced water is not expected to effect stock watering. Salinity values as high as 3,500 mg/L TDS are still considered suitable for consumption by livestock. Many CBM produced waters are likely to have elevated salinity and concentrations of sodium, which can affect the suitability of the produced water for irrigation purposes. Because of the potential adverse effects from CBM produced water discharges on the quality of surface waters used for irrigation, mass balance calculations were performed to project the suitability of the CBM produced water for irrigation purposes, when commingled with existing surface flows in the receiving streams. Effects from CBM discharges on downstream irrigation use, prior to commingling with existing surface flows in the receiving streams, would be analyzed by WDEQ under the NPDES program.

Mass balance calculations of CBM surface discharge contributions to existing water quality and flow data were performed to provide an estimate of flow, salinity, and SAR expected in the year 2002 when the Project is implemented. Mass balance calculations were performed using flow-weighted averages. Available water quality data for currently producing CBM wells are summarized in Table 3–2. Projected future flows of CBM produced water are summarized in Tables 2–8 and 2–32. Existing surface water quality and flow data by sub-watershed are provided in Appendix E and Table 3–5, respectively. For the purposes of the analysis, the following assumptions were used. Mass balance calculations assume that the CBM produced water discharges reach the receiving streams at the sub-watershed boundary unchanged in water quality. Baseline water quality of the receiving streams is assumed to be the same during low flow conditions as during average flow conditions.

The results of the mass balance calculations were utilized to project the combined effect on the quality of the water for irrigation purposes. Effects were analyzed utilizing Figure 4–12, which provides guidelines for assessing potential effects on infiltration associated with SAR and salinity levels in irrigation waters (Hansen et al. 1999). The diagonal line indicating “No Reduction in Infiltration” illustrates the combination of SAR and salinity values that can be expected to reduce

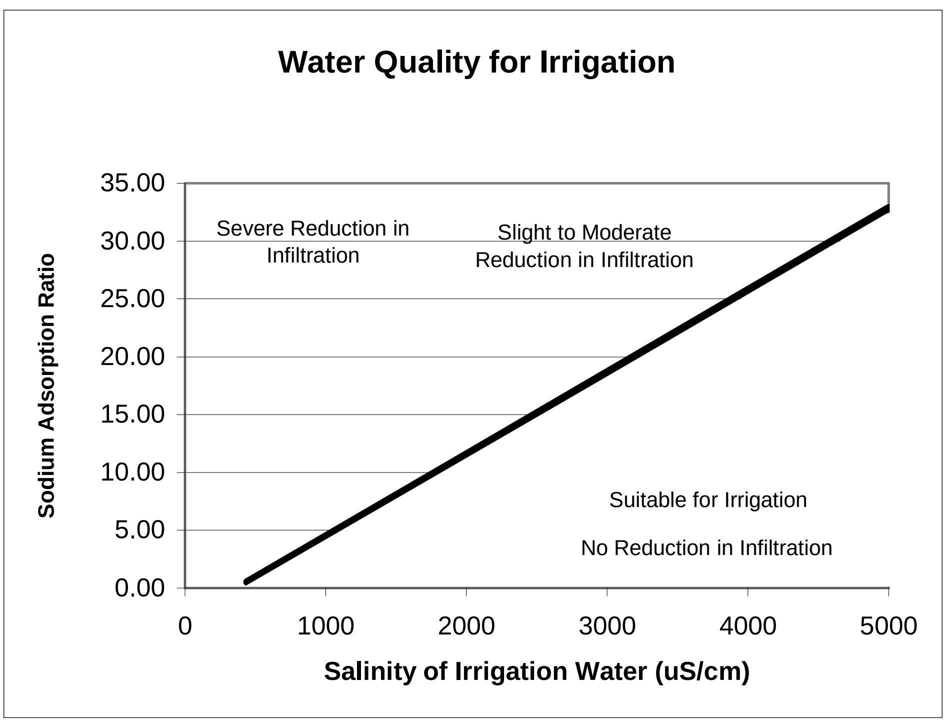


Figure 4–12 Effects of Salinity and SAR on Infiltration

the infiltration capacity of a wide variety of soils, and thus, effect the suitability of the water for irrigation. This line is referred to as the Hanson Line in the figures that follow. Salinity is expressed as specific conductance in microSiemans per centimeter (µS/cm).

Upper Tongue River Sub-Watershed

Effects on water quality in the Upper Tongue River are illustrated in Figure 4–13 and Figure 4–14. Limited information is currently available on CBM water production and quality in the Tongue River sub-watershed. For the purpose of this analysis, CBM water quality was based on samples from CBM wells located in Montana, just outside the Project Area. The representative water quality has a salinity of 2,099 µS/cm and an SAR of 52 (AHA 2000).

The additional flow attributable to produced water (3.4 cfs) would result in very minor contributions to the flow of the Tongue River. Salinity values would increase slightly above existing conditions, from 513 to 532 µS/cm. SAR values would increase from 0.5 to 1.1. The estimated increases in salinity and SAR from CBM discharges in the Tongue River sub-watershed would not alter the irrigation suitability of the Upper Tongue River.

Under Alternative 1, CBM discharges in the Upper Tongue River sub-watershed would undergo treatment prior to discharge. Water quality effects would be minimized, depending on the level and method of treatment.

Upper Powder River Sub-Watershed

Effects on water quality in the Upper Powder River are illustrated in Figure 4–15 and Figure 4–16. Representative water quality from CBM wells in the sub-watershed has an average salinity of 2,428 µS/cm and an average SAR of 13.5 (Energy Labs 2001).

Flows expected from CBM produced water discharges (22.2 cfs) would result in slight contributions to the flow of the Upper Powder River. Salinity values would increase slightly above existing conditions, from 2,057 to 2,101 µS/cm. SAR values would increase from 4.8 to 5.8. The water in the Upper Powder River would be expected to remain suitable for irrigation purposes.

Salt Creek Sub-Watershed

Currently there is no CBM development in the Salt Creek sub-watershed, so mass balance calculations could not be performed. Existing water quality in Salt Creek is high in salinity (5,797 µS/cm) and SAR (15.5). With CBM flows of 0.02 cfs projected for the sub-watershed, the combined water quality would likely remain unchanged. The water in Salt Creek is of poor quality for livestock consumption due to the high salinity.

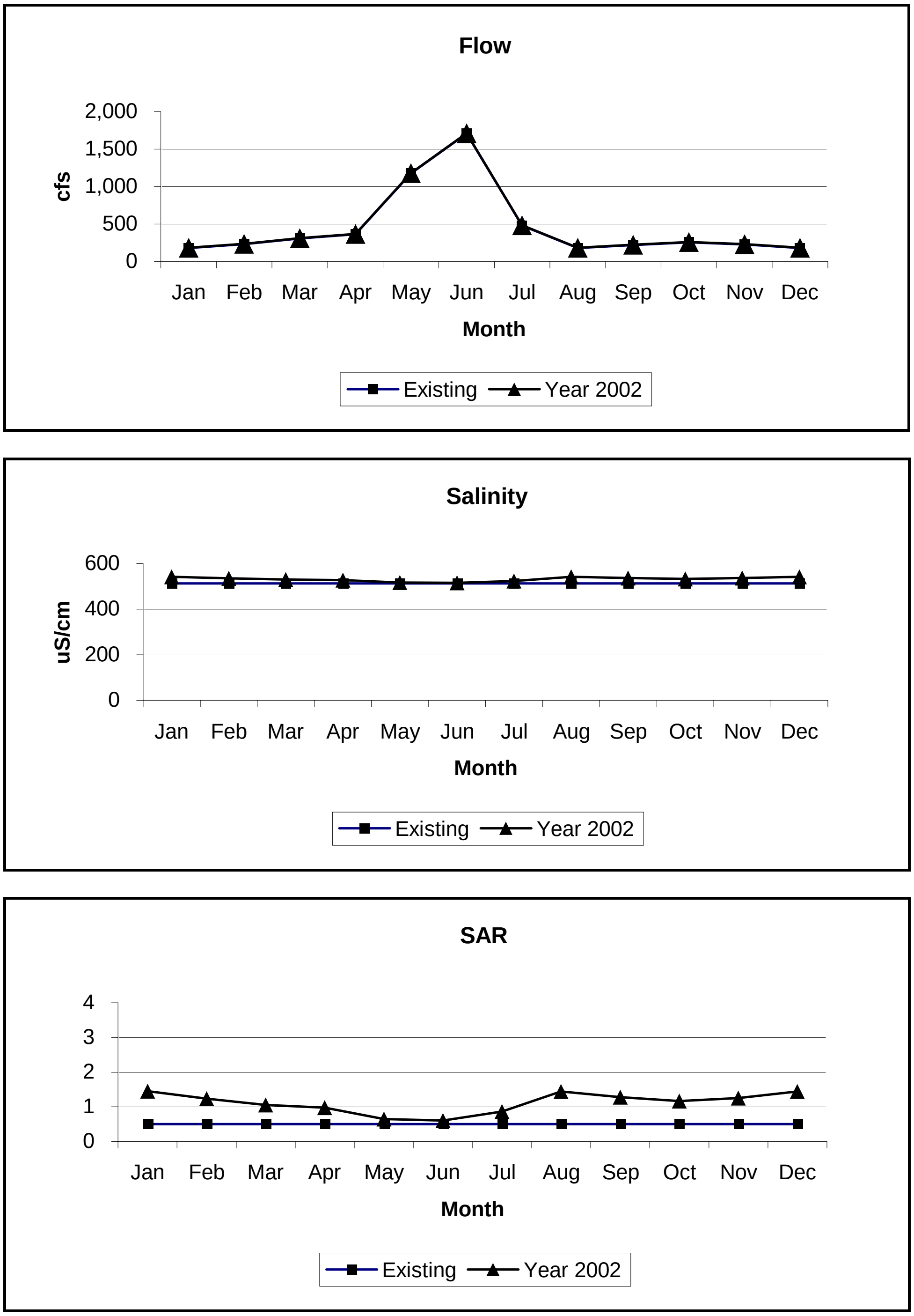


Figure 4–13 Existing and Projected Water Quality in Year 2002 — Upper Tongue River Sub-Watershed

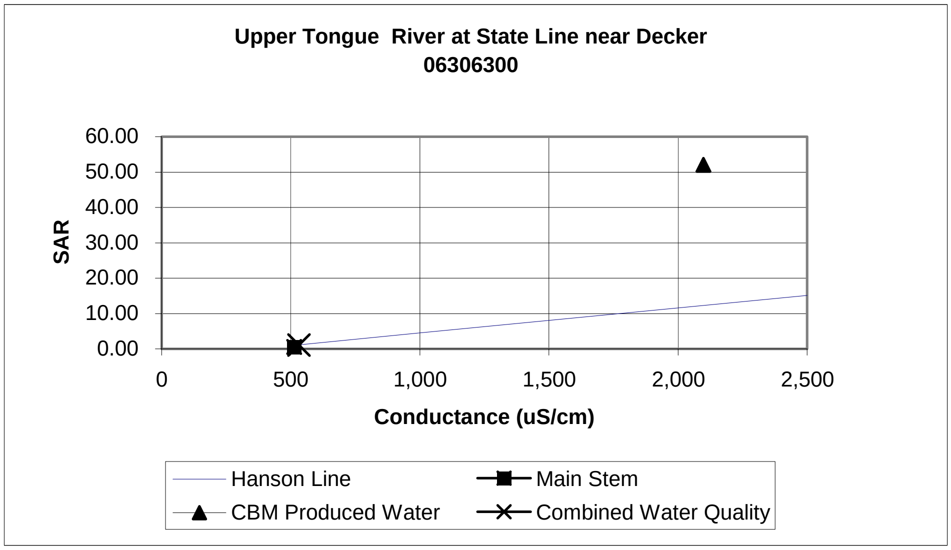


Figure 4–14 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Tongue River Sub-Watershed

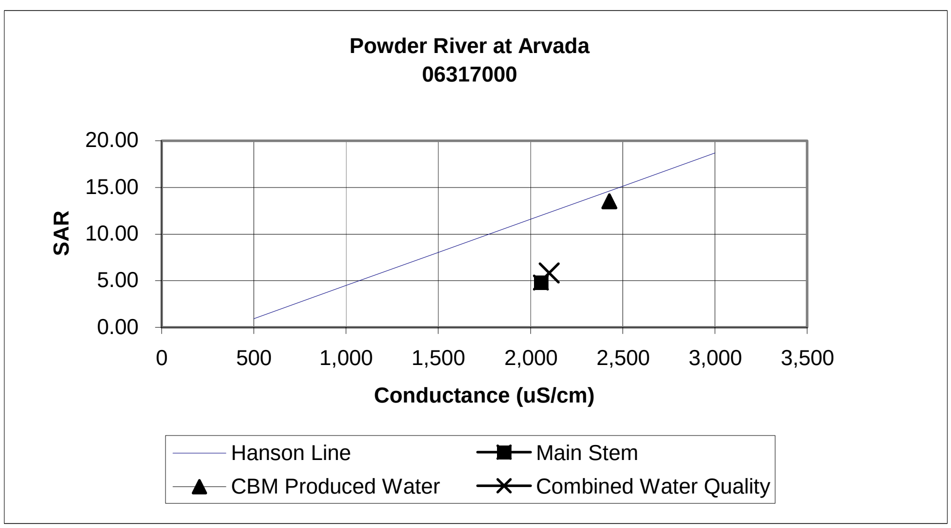
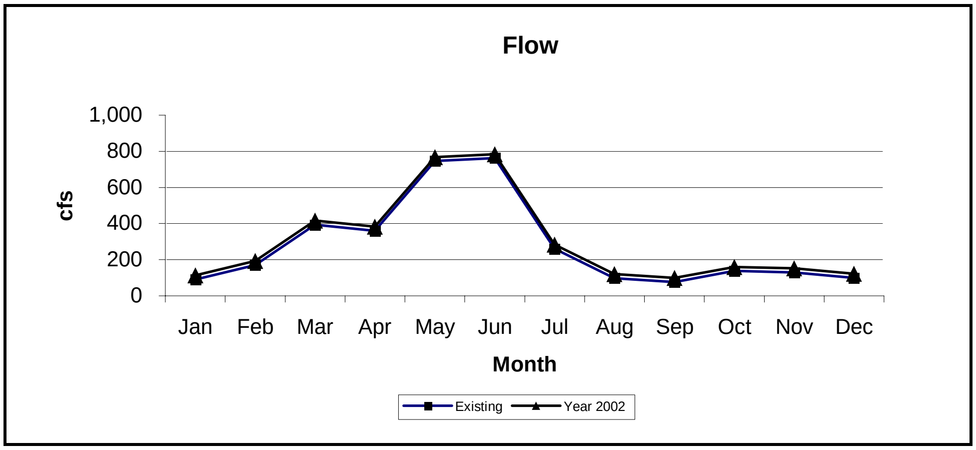
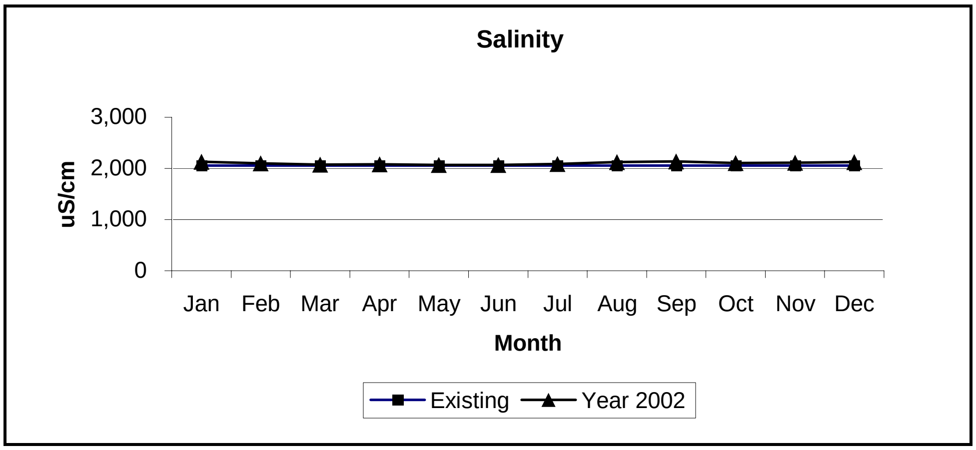


Figure 4–15 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Powder River Sub-Watershed





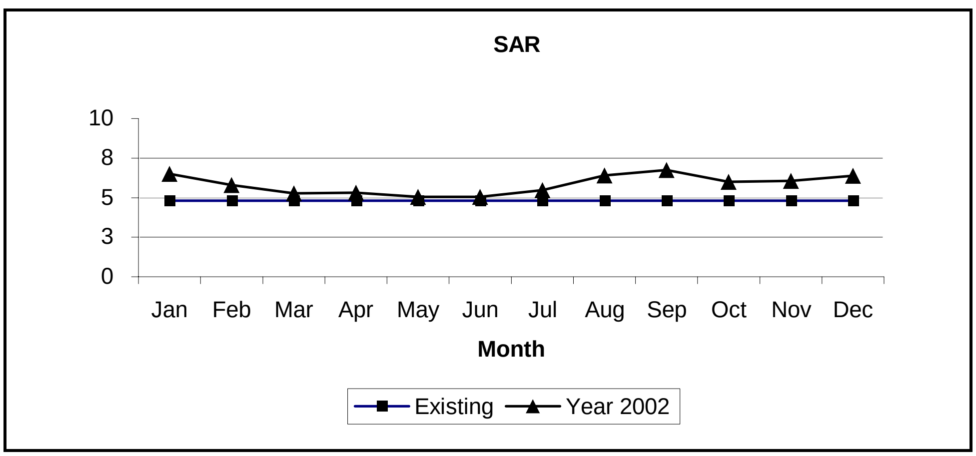


Figure 4–16 Existing and Projected Water Quality in Year 2002 — Upper Powder River Sub-Watershed

Crazy Woman Creek Sub-Watershed

Effects on water quality in Crazy Woman Creek are illustrated in Figure 4–17 and Figure 4–18. For the purpose of this analysis, water quality data from existing CBM wells in the Upper Powder River sub-watershed were assumed to be representative of water produced in the Crazy Woman Creek sub-watershed. CBM produced water from the Upper Powder River sub-watershed has an average salinity of 2,428 µS/cm and an average SAR of 13.5 (Energy Labs 2001).

Flows expected from CBM produced water discharges (2.8 cfs) would result in slight contributions to existing flows in Crazy Woman Creek. Salinity values would increase from 1,185 to 1,306 µS/cm. SAR values would increase from 2.0 to 3.1. The water in Crazy Woman Creek would be expected to remain suitable for irrigation purposes.

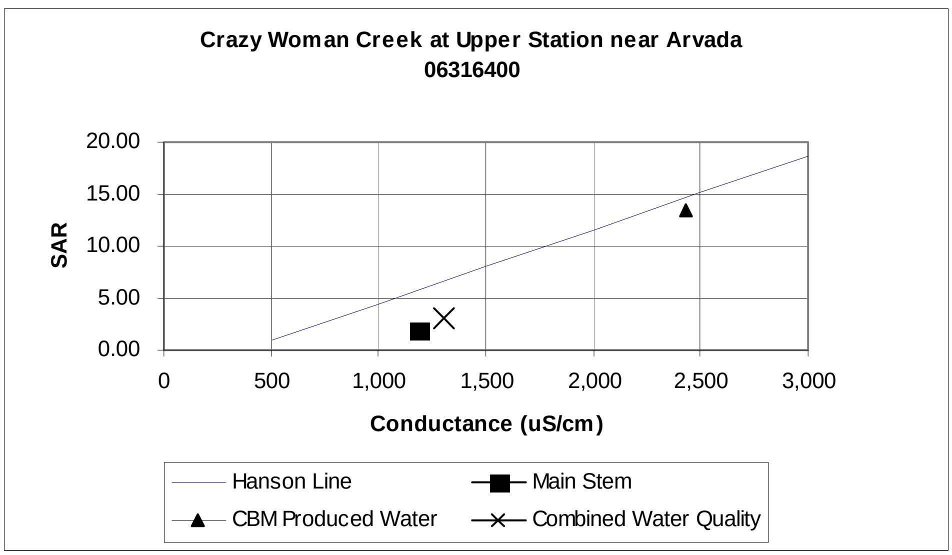


Figure 4–17 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Crazy Woman Creek Sub-Watershed

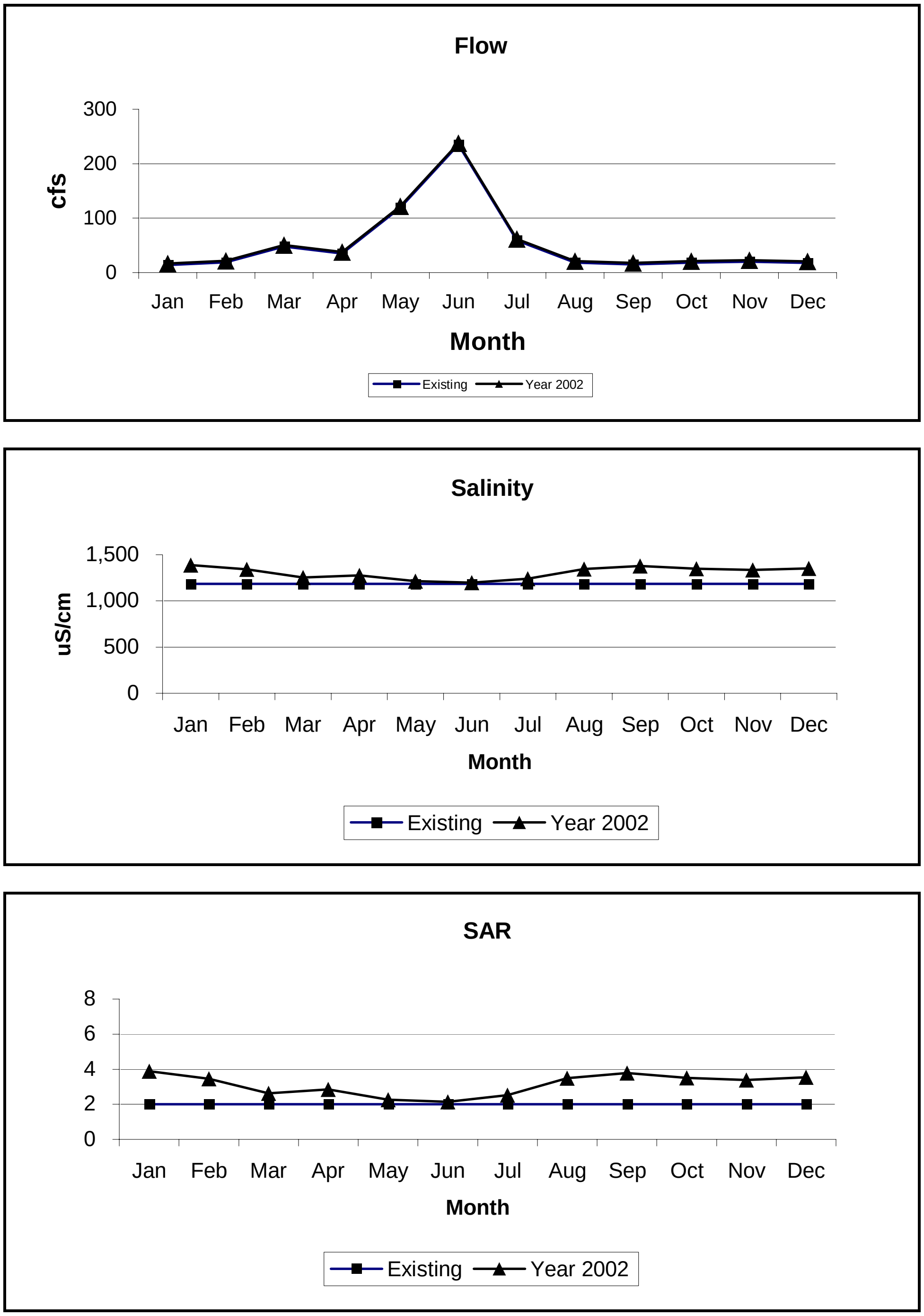


Figure 4–18 Existing and Projected Water Quality in Year 2002 — Crazy Woman Creek Sub-Watershed

Clear Creek Sub-Watershed

Effects on water quality in Clear Creek are illustrated in Figure 4–19 and Figure 4–20. For the purpose of this analysis, water quality data from existing CBM wells in the Upper Powder River sub-watershed were assumed to be representative of water produced in the Clear Creek sub-watershed. CBM produced water from the Upper Powder River sub-watershed has an average salinity of 2,428 µS/cm and an average SAR of 13.5 (Energy Labs 2001).

The additional flow attributable to produced water (2.4 cfs) would result in very minor contributions to the flow of Clear Creek. Salinity values would increase slightly above existing conditions, from 1,141 to 1,167 µS/cm. SAR values would increase from 1.1 to 1.4. The slight increases in salinity and SAR from CBM discharges in the Clear Creek sub-watershed would not alter the irrigation suitability of Clear Creek. The combined water quality would be expected to be suitable for irrigation.

Under Alternative 1, about one-third of the CBM discharges in this watershed would be treated prior to discharge. Effects on water quality in Clear Creek would be minimized, depending on the level and method of treatment.

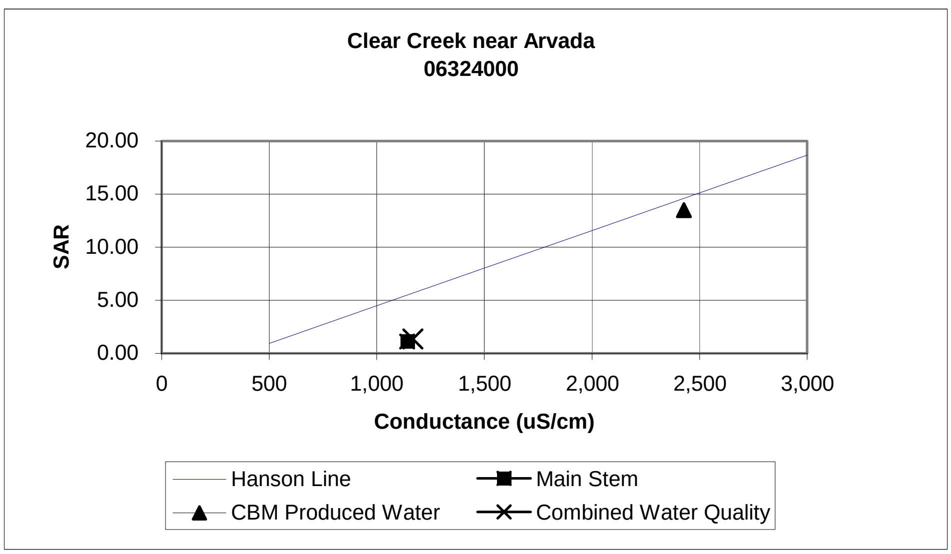


Figure 4–19 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Clear Creek Sub-Watershed

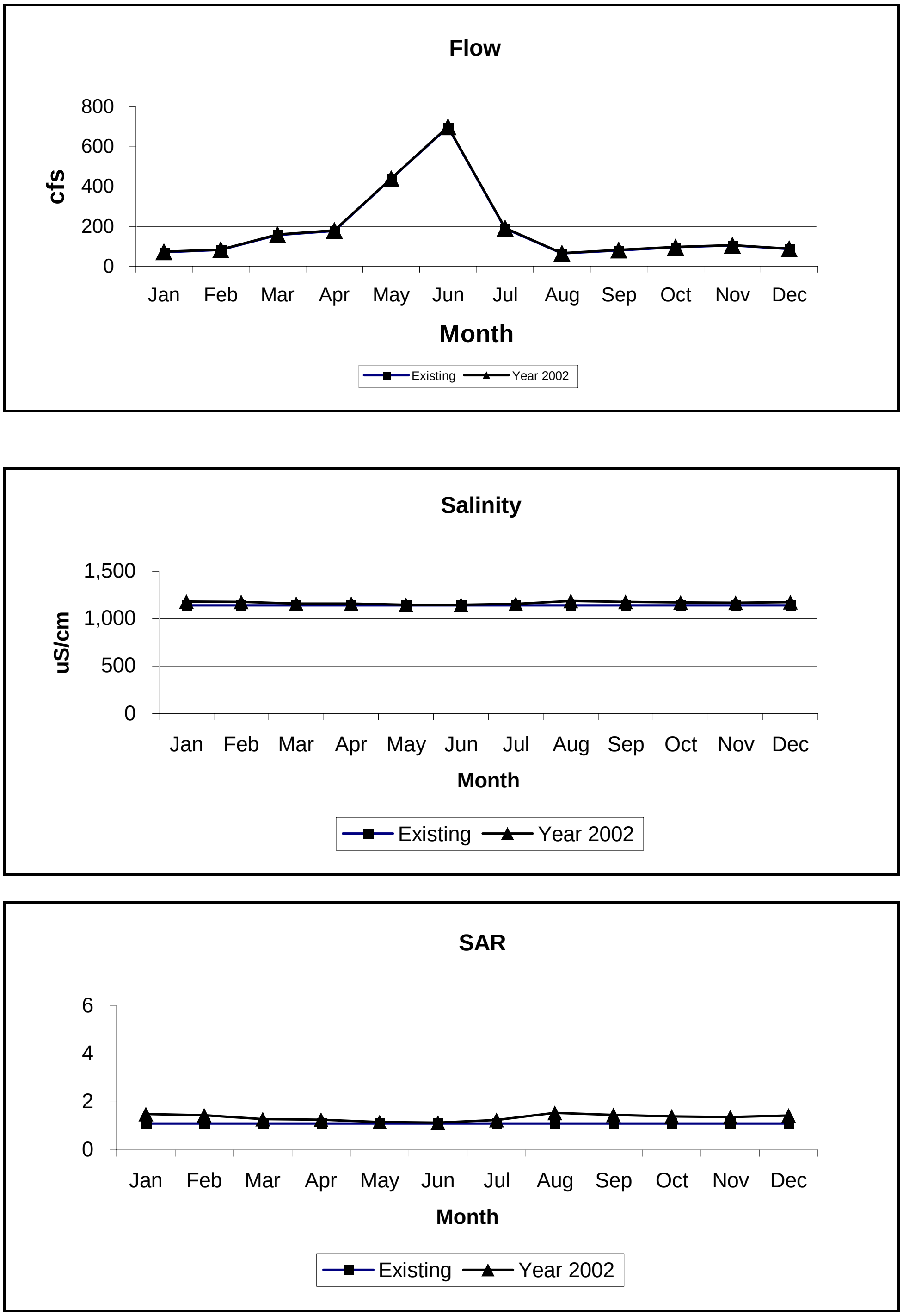


Figure 4–20 Existing and Projected Water Quality in Year 2002 — Clear Creek Sub-Watershed

Middle Powder River Sub-Watershed

Effects on water quality in the Middle Powder River are illustrated in Figure 4–21 and Figure 4–22. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 3,423 µS/cm and an SAR of 3.7 (Energy Laboratories 2001).

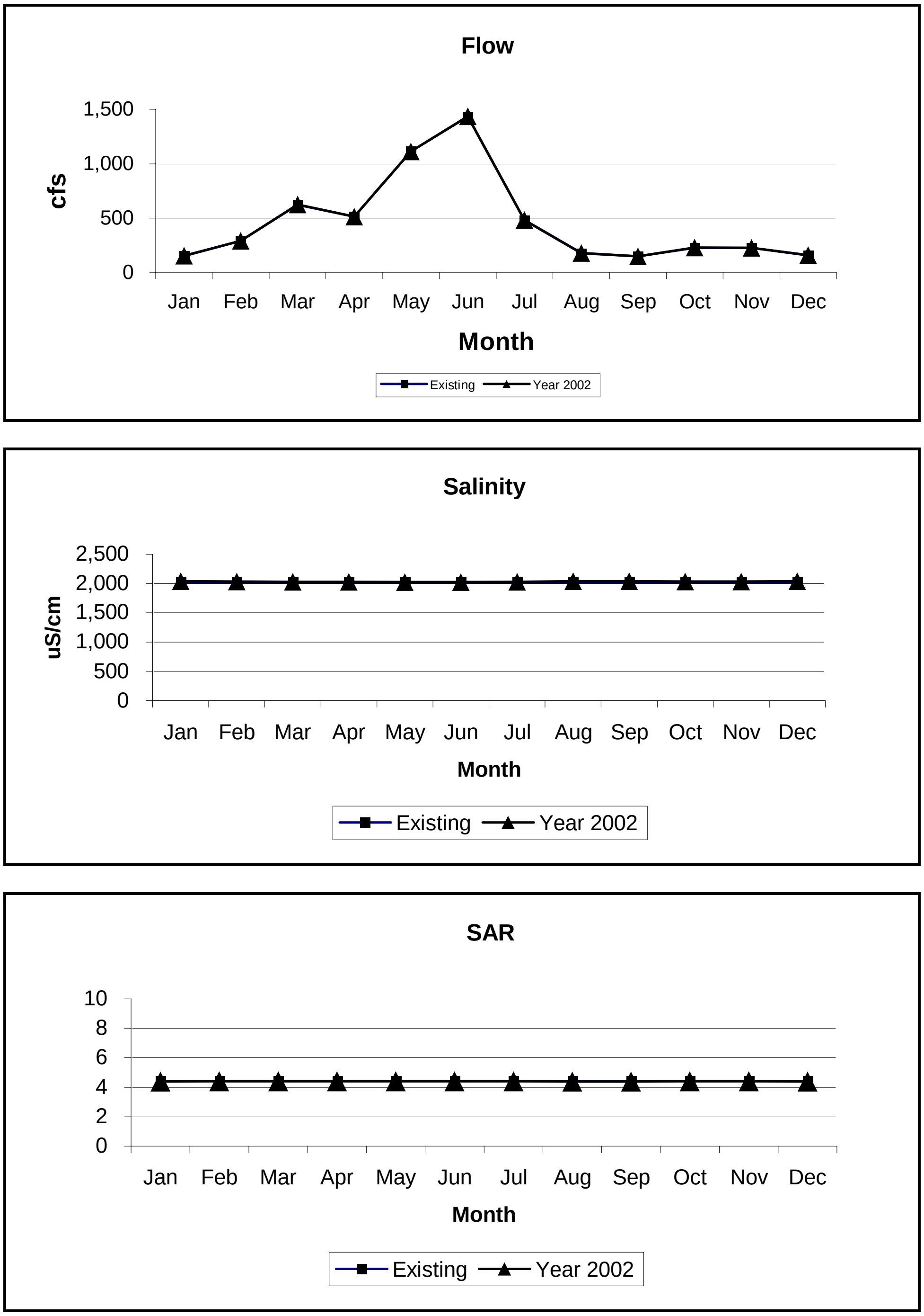


Figure 4–21 Existing and Projected Water Quality in Year 2002 — Middle Powder River Sub-Watershed

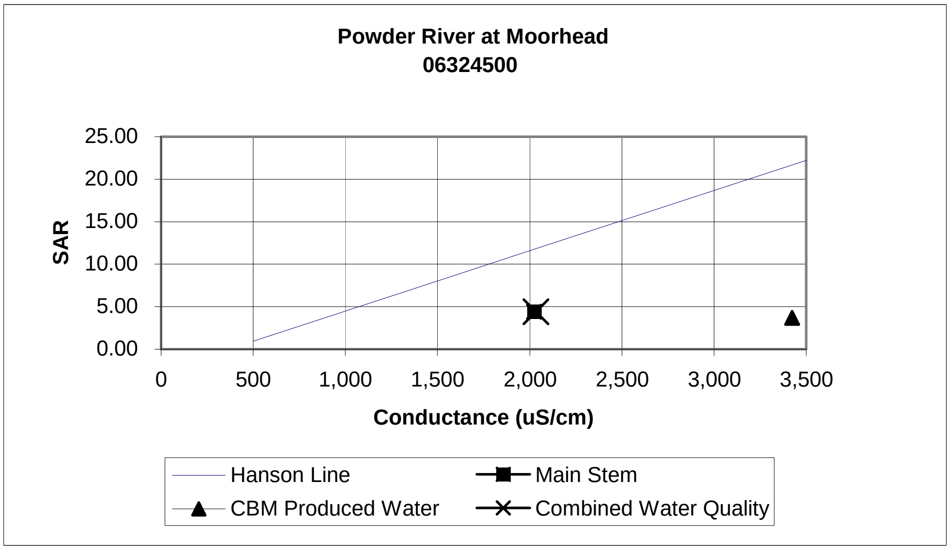


Figure 4–22 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Middle Powder River Sub-Watershed

CBM produced water flows (2.0 cfs) would result in very minor contributions to the flow of the Middle Powder River. Salinity values would increase slightly above existing conditions, from 2,023 to 2,033 µS/cm. SAR values would remain at 4.4. The projected increase in salinity would not significantly alter the irrigation suitability of the Middle Powder River, which is currently of acceptable quality for irrigation of most soil types.

Little Powder River Sub-Watershed

Effects on water quality in the Little Powder River are illustrated in Figure 4–23 and Figure 4–24. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 2,048 µS/cm and an SAR of 8.9 (Energy Laboratories 2001).

The additional flow attributable to produced water (2.6 cfs) would result in very minor contributions to the flow of the Little Powder River. Salinity values would decline below existing conditions, from 2,737 to 2,593 µS/cm. SAR values would increase from 6.1 to 6.8. The projected decrease in salinity and increase in SAR would not significantly alter the irrigation suitability of the Little Powder River, which is currently of acceptable quality for irrigation of most soil types.

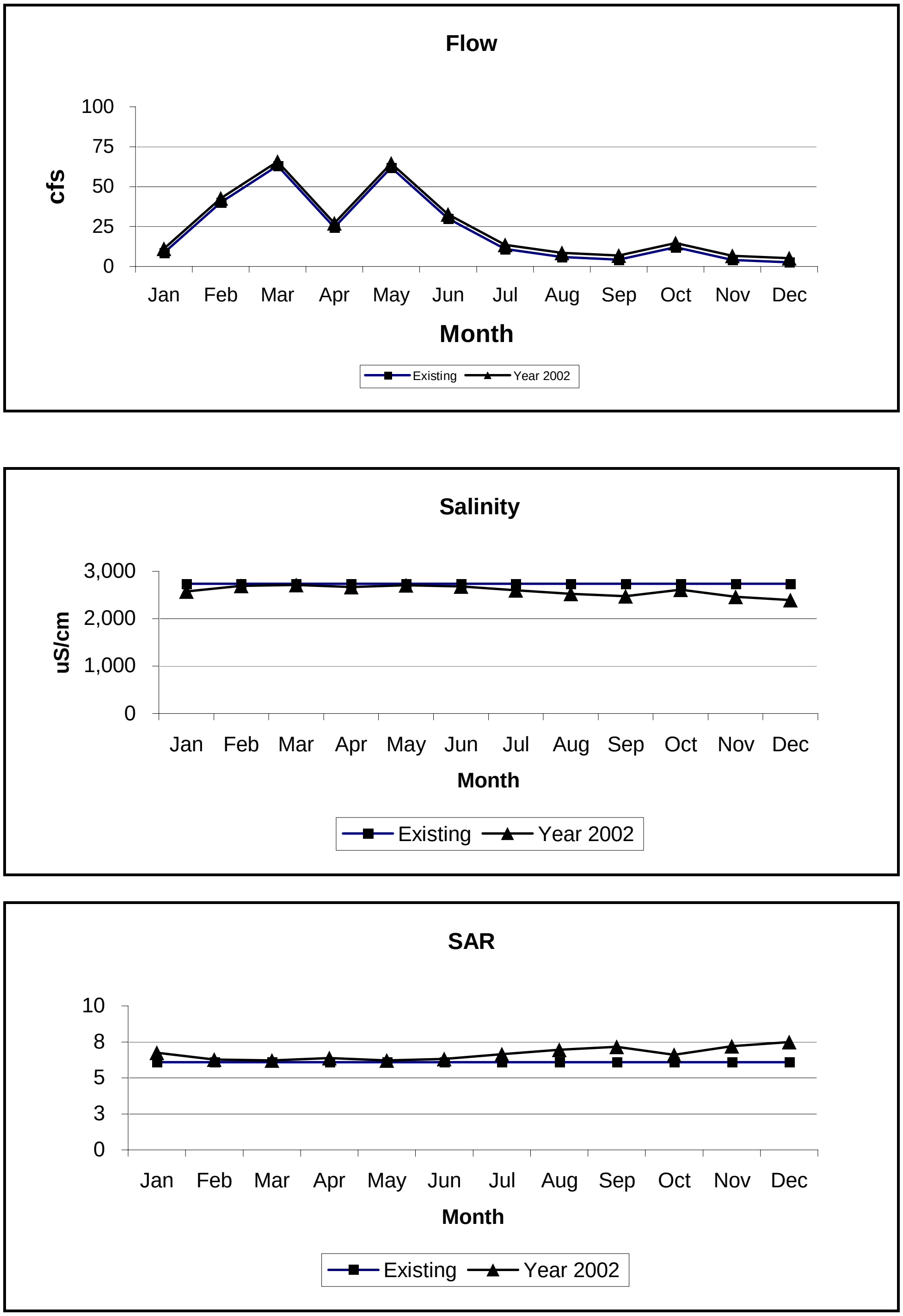


Figure 4–23 Existing and Projected Water Quality in Year 2002 — Little Powder River Sub-Watershed

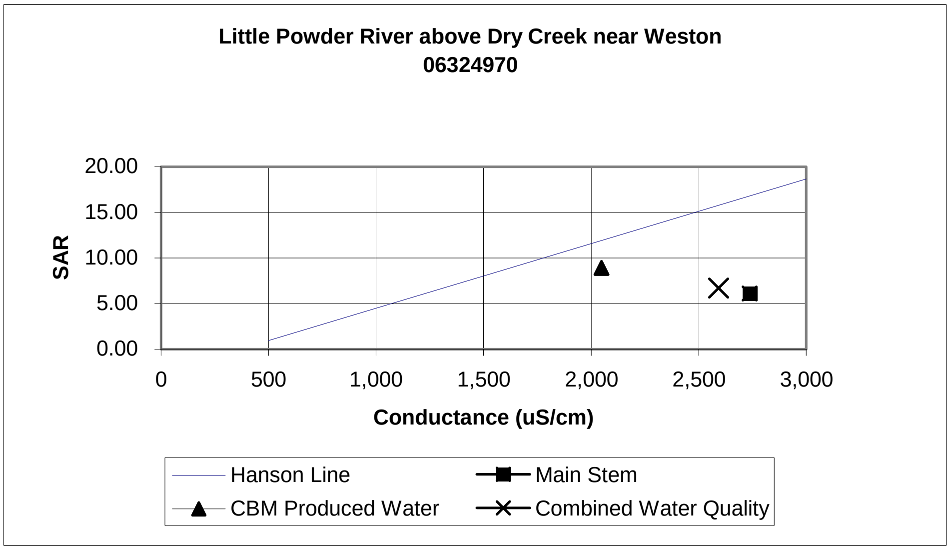


Figure 4–24 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Little Powder River Sub-Watershed

Antelope Creek Sub-Watershed

Effects on water quality in Antelope Creek are illustrated in Figure 4–25 and Figure 4–26. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality from has a salinity of 1,130 µS/cm and an SAR of 7.3 (Energy Laboratories 2001).

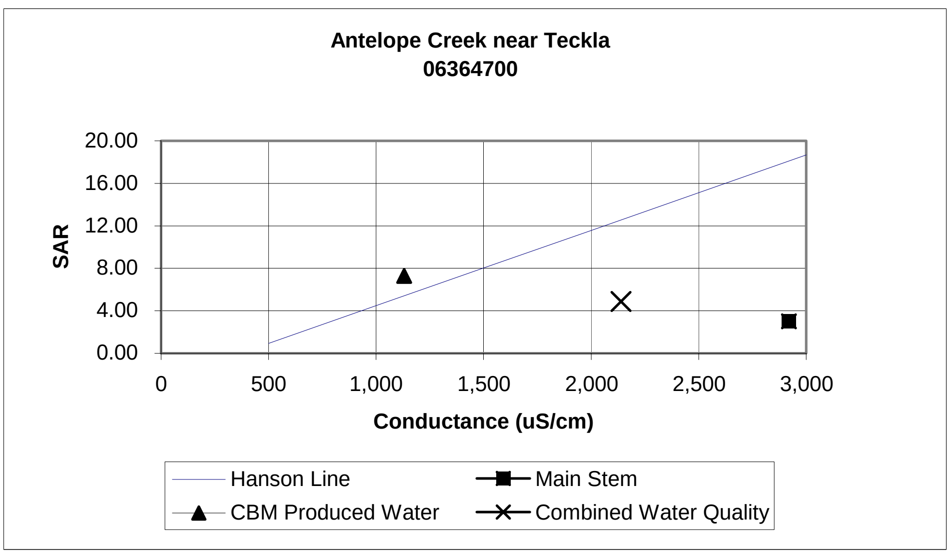


Figure 4–25 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Antelope Creek Sub-Watershed

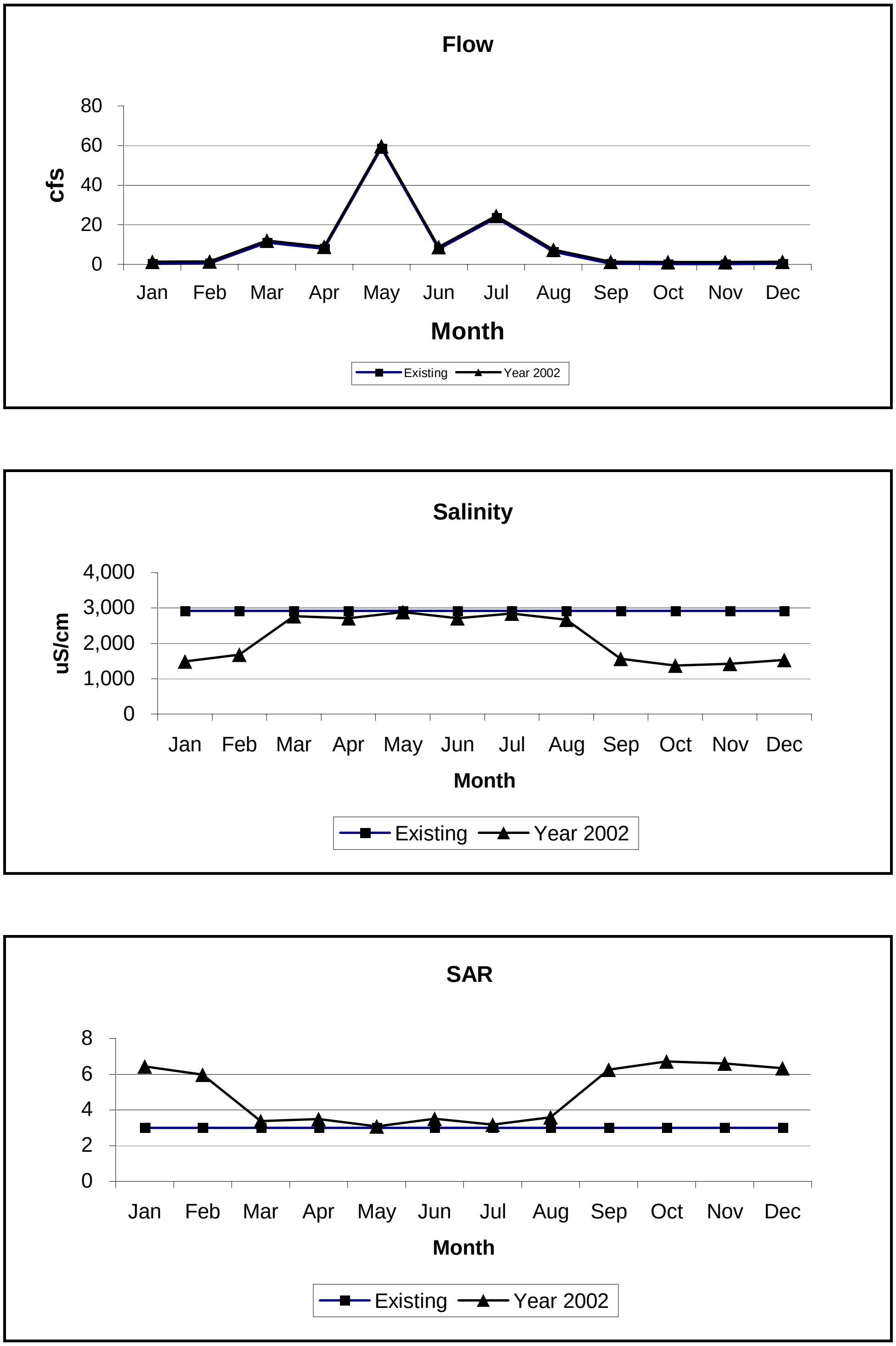


Figure 4–26 Existing and Projected Water Quality in Year 2002 — Antelope Creek Sub-Watershed

The additional flow attributable to produced water (0.9 cfs) would result in very minor contributions to the flow of Antelope Creek. Salinity values would decrease below existing conditions, from 2,920 to 2,138 µS/cm. SAR values would increase from 3.0 to 4.9. The projected decrease in salinity and increase in SAR would not significantly alter the irrigation suitability of Antelope Creek as both values would approach baseline levels during the irrigation months. The combined water quality would be expected to be suitable for irrigation.

Upper Cheyenne River Sub-Watershed

Effects on water quality in the Upper Cheyenne River are illustrated in Figure 4–27 and Figure 4–28. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 787 µS/cm and an SAR of 7.0 (Energy Laboratories 2001).

The additional flow attributable to produced water (0.6 cfs) would result in very minor contributions to the flow of the Cheyenne River. Salinity values would decrease below existing conditions, from 3,321 to 3,025 µS/cm. SAR values would remain approximately 7.3. The projected decrease in salinity from CBM discharges in the Upper Cheyenne River sub-watershed would not be expected to alter the irrigation suitability of the Cheyenne River which is suitable for irrigation of most soil types.

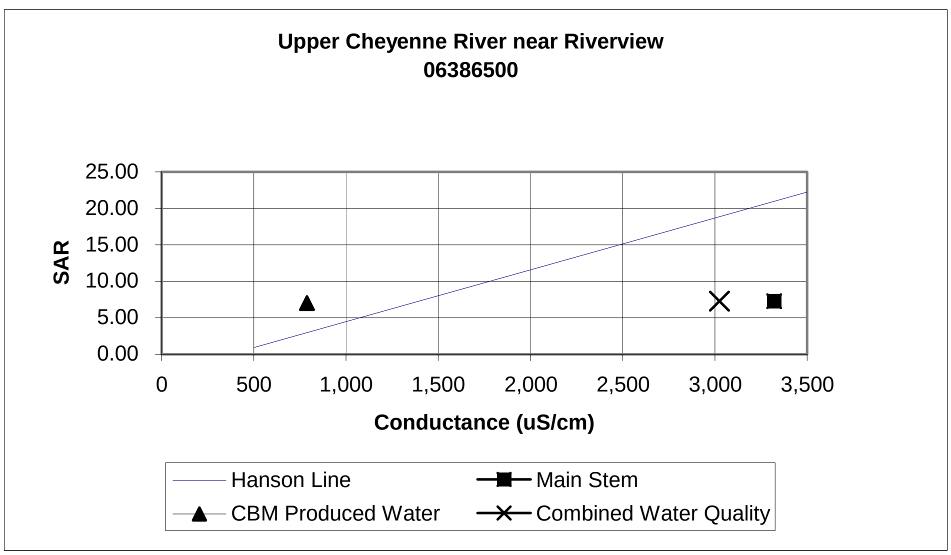


Figure 4–27 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Cheyenne River Sub-Watershed

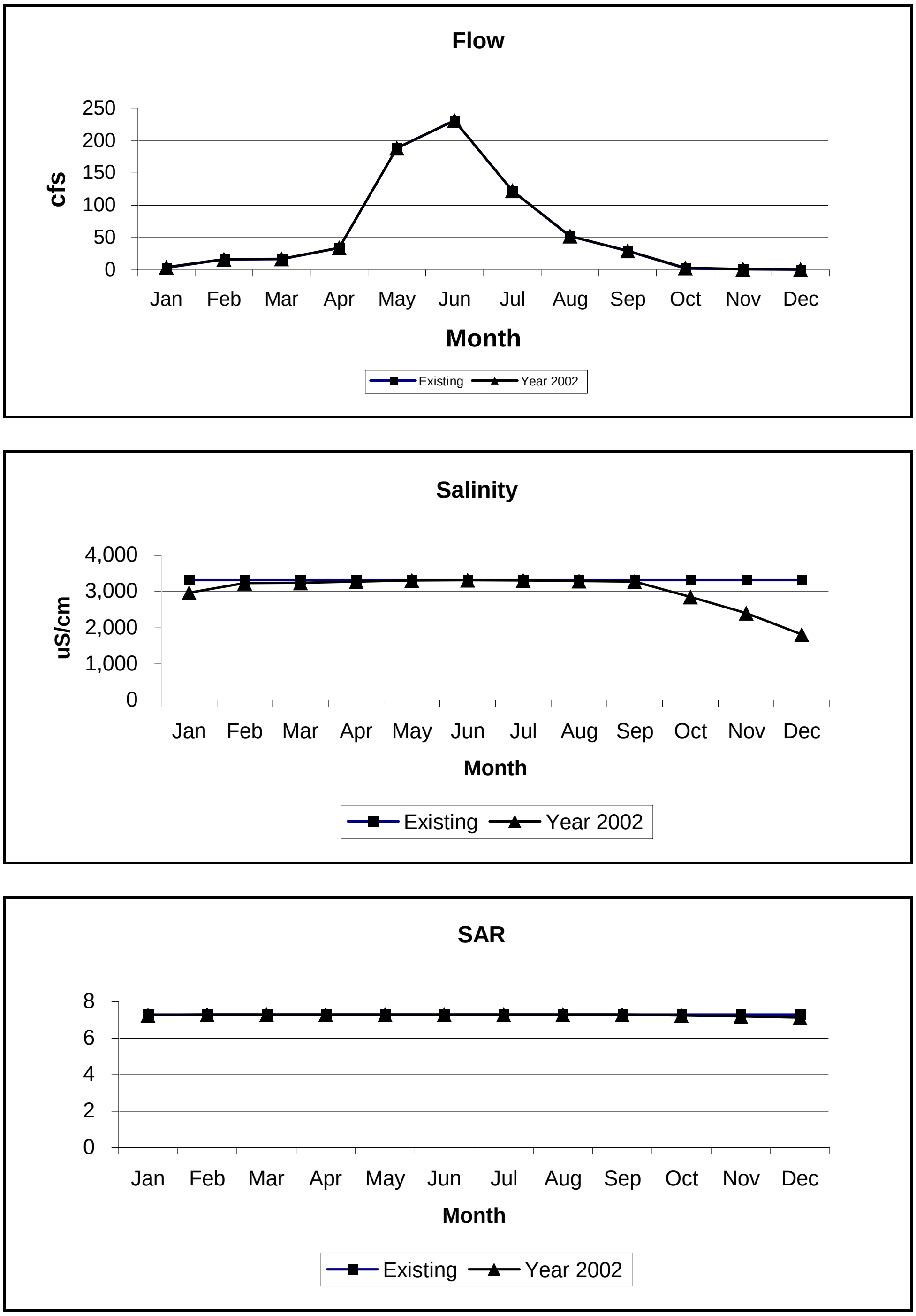


Figure 4–28 Existing and Projected Water Quality in Year 2002 — Upper Cheyenne River Sub-Watershed

Upper Belle Fourche River Sub-Watershed

Effects on water quality in the Upper Belle Fourche River are illustrated in Figure 4–29 and Figure 4–30. Representative CBM water quality was based on samples from existing CBM wells located in the sub-watershed. The CBM water quality has a salinity of 1,202 µS/cm and an SAR of 9.1 (Energy Laboratories 2001).

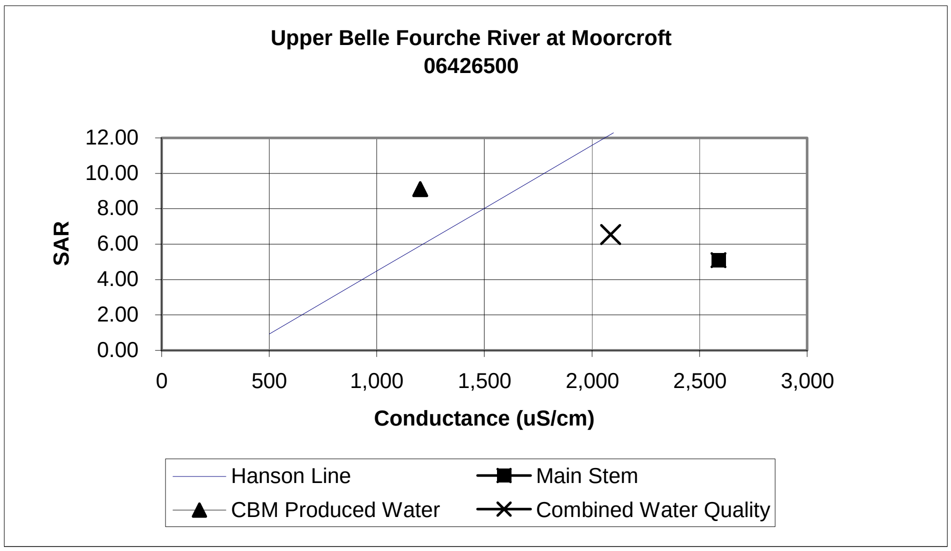
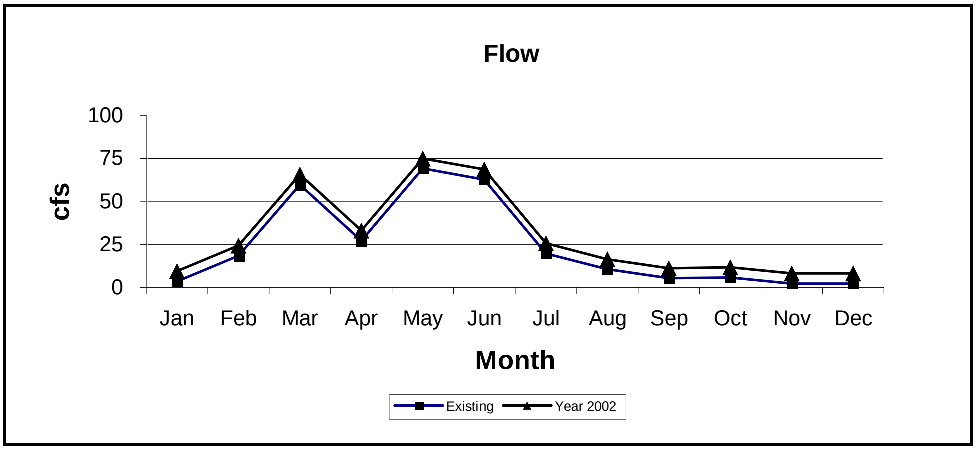
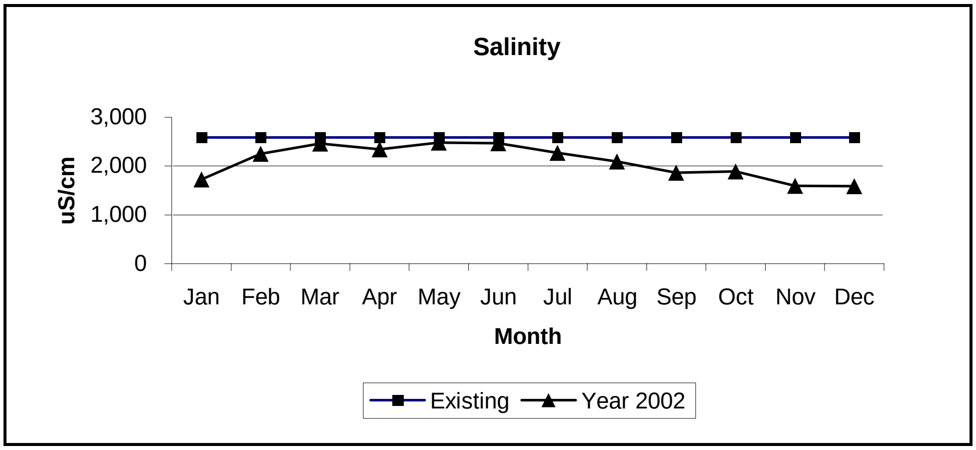


Figure 4–29 Projected Effects of Salinity and SAR on Infiltration in Year 2002 — Upper Belle Fourche River Sub-Watershed

The additional flow attributable to produced water (5.9 cfs) would result in very minor contributions to the flow of the Upper Belle Fourche River. Salinity values would decrease below existing conditions, from 2,588 to 2,087 µS/cm. SAR values would increase from 5.1 to 6.5. The projected decrease in salinity and increase in SAR would not alter the irrigation suitability of the Belle Fourche River as both values would approach baseline levels during irrigation months. The combined water quality would be expected to be suitable for irrigation, based on Year 2002 projections.

Over the life of the project, effects on surface water quality and the suitability of surface waters for irrigation purposes, when commingled with CBM discharges, are expected to be comparable to the effects illustrated in the year 2002, assuming the water handling percentages remain unchanged. Mass balance calculations were performed using the same methodology and assumptions described earlier in this section for Year 2002 impacts. These mass balance calculations assume that the representative water quality of the CBM discharges and surface water quality and stream flows remain constant throughout the life of the Project.





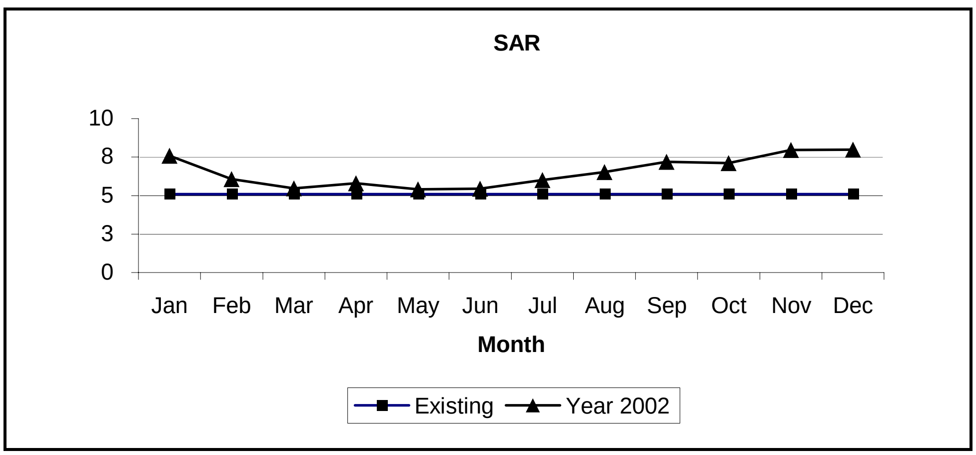


Figure 4–30 Existing and Projected Water Quality Effects in Year 2002 — Upper Belle Fourche River Sub-Watershed

Table 4–6 summarizes the mass balance calculations by sub-watershed. Separate calculations were performed for the irrigations months of May through July, when concern for the suitability of the water for irrigation is greatest. The projected effects of salinity and SAR on infiltration are illustrated by sub-watershed in Figure 4–31 through Figure 4–39. Water quality in the receiving streams would be expected to remain of suitable quality for irrigation purposes, except for the Upper Tongue River and the Upper Belle Fourche River. Restrictions on salinity and SAR levels would be managed through the WDEQ's permitting process to protect these streams for use for irrigation.

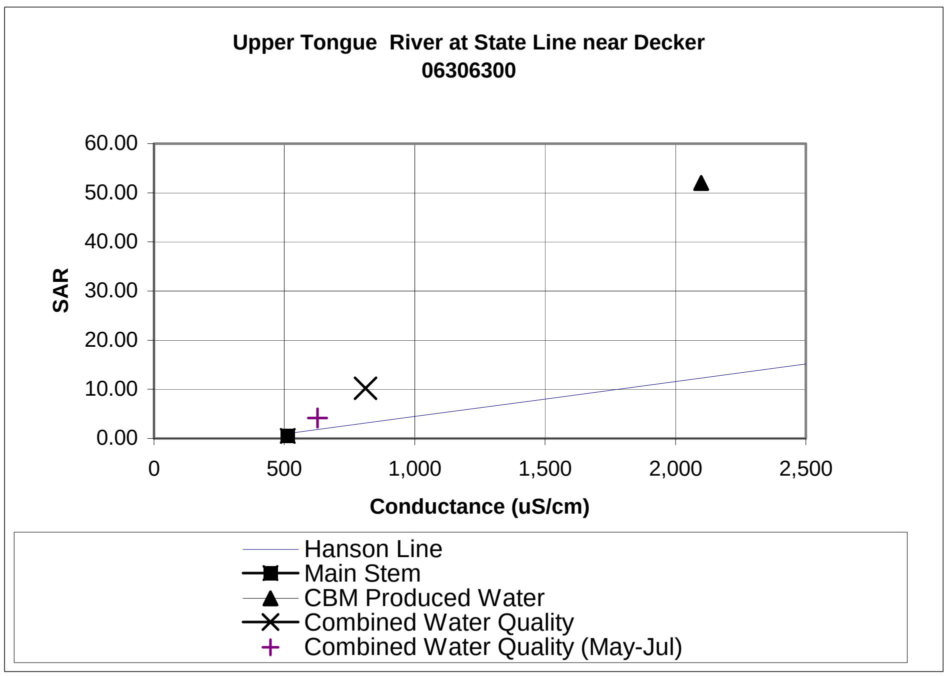


Figure 4–31 Projected Effects of Salinity and SAR on Infiltration over Project Life — Upper Tongue River Sub-Watershed

Table 4–6 Projected Surface Flows and Water Quality at Sub-watershed Boundary — Project Life

Sub-Watershed	Station	Predicted CBM Discharge (cfs)	Mean CBM Conductance (uS/cm)	Mean CBM SAR	Mean Stream Flow (cfs)	Mean Stream Conductance (uS/cm)	Mean Stream SAR	Combined Flow (cfs)	Combined Conductance (uS/cm)	Combined SAR
Upper Tongue River	Upper Tongue River at State Line near Decker	67.3	2,099	52.0	460.0	513	0.5	527.3	811	10.2
								1122 (Irr)[1]	627 (Irr)	4.2 (Irr)
Upper Powder River	Upper Powder River at Arvada	342.4	2,428	13.5	277.2	2,057	4.8	619.6	2286	10.2
								932.0 (Irr)	2204 (Irr)	8.3 (Irr)
Crazy Woman Creek	Crazy Woman Creek at Upper Station near Arvada	61.0	2,428	13.5	51.6	1,185	2.0	112.6	1981	9.4
								198.6 (Irr)	1622 (Irr)	6.0 (Irr)
Clear Creek	Clear Creek near Arvada	75.0	2,428	13.5	187.5	1,141	1.1	262.5	1620	5.7
								517.3 (Irr)	1367 (Irr)	3.3 (Irr)
Middle Powder River	Middle Powder River at Moorhead, MT	16.7	3,423	3.7	462.5	2,023	4.4	479.2	2103	4.4
								1025 (Irr)	2051 (Irr)	4.4 (Irr)
Little Powder River	Little Powder River above Dry Creek near Weston	18.8	2,048	8.9	22.3	2,737	6.1	41.1	2346	7.7
								53.1 (Irr)	2450 (Irr)	7.3 (Irr)
Antelope Creek	Antelope Creek near Teckla	17.3	1,130	7.3	9.8	2,920	3.0	27.1	1537	6.3
								47.3 (Irr)	2120 (Irr)	4.9 (Irr)
Upper Cheyenne River	Upper Cheyenne River near Riverview	5.2	787	7.0	58.0	3,321	7.3	63.2	2478	7.2
								185.5 (Irr)	3245 (Irr)	7.3 (Irr)
Upper Belle Fourche River	Upper Belle Fourche River near Moorcroft	54.0	1,202	9.1	23.9	2,588	5.1	77.9	1546	8.1
								123.2 (Irr)	1834 (Irr)	7.3 (Irr)

Notes:
1 Irr = Projected during the irrigation months of May, June, July

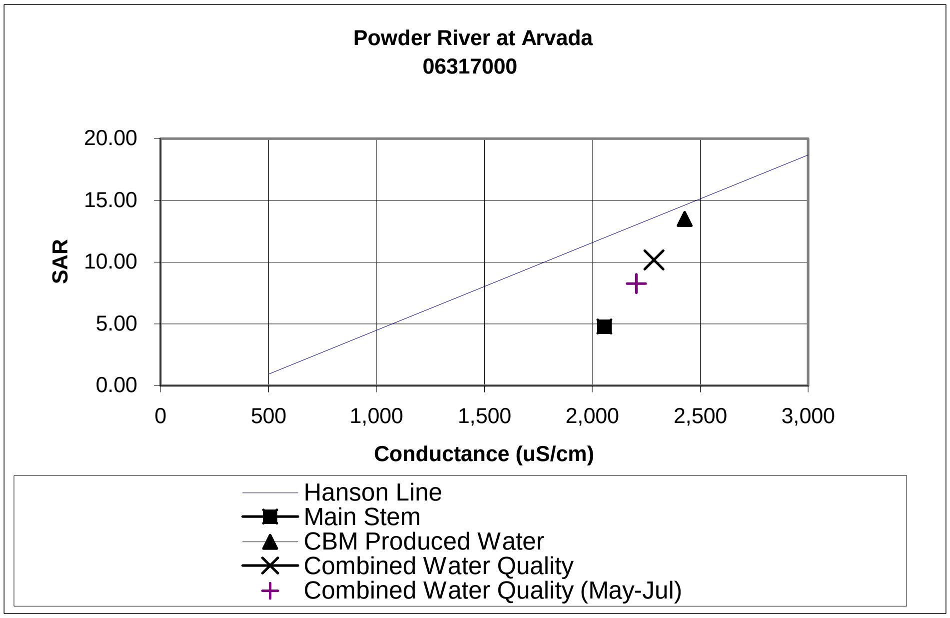


Figure 4–32 Projected Effects of Salinity and SAR on Infiltration over Project Life — Upper Powder River Sub-Watershed

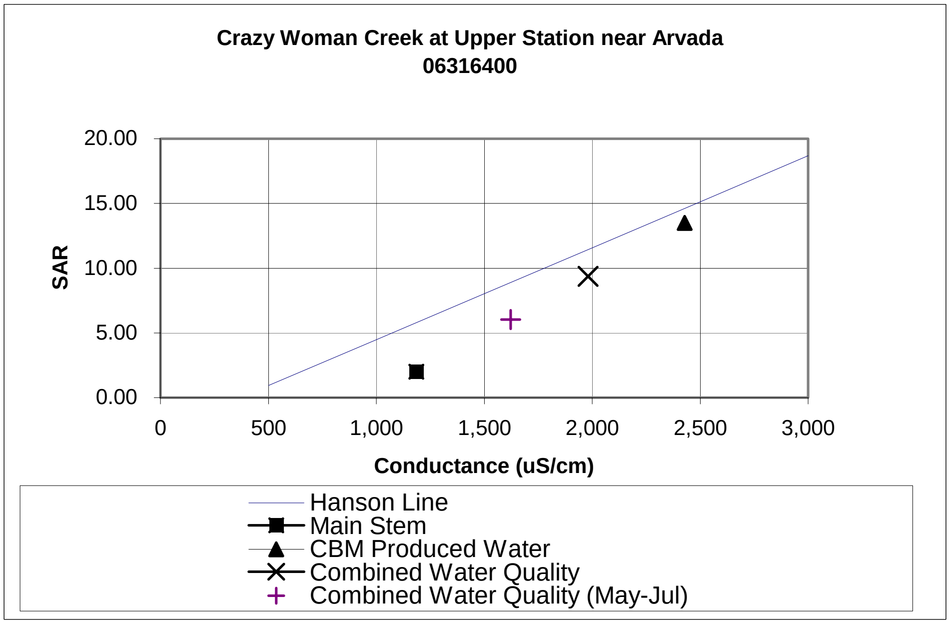


Figure 4–33 Projected Effects of Salinity and SAR on Infiltration over Project Life – Crazy Woman Creek Sub-Watershed

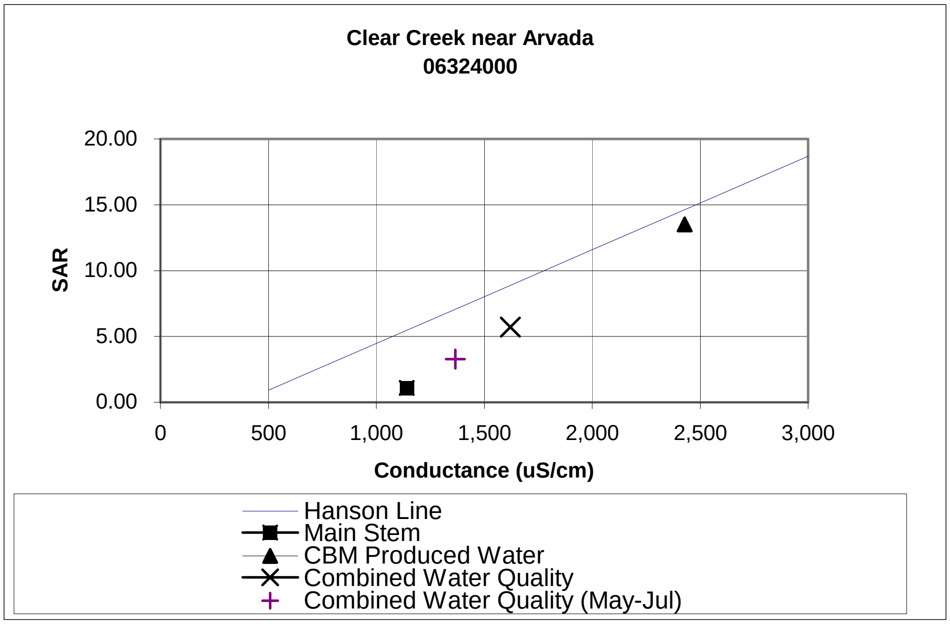


Figure 4–34 Projected Effects of Salinity and SAR on Infiltration over Project Life – Clear Creek Sub-Watershed

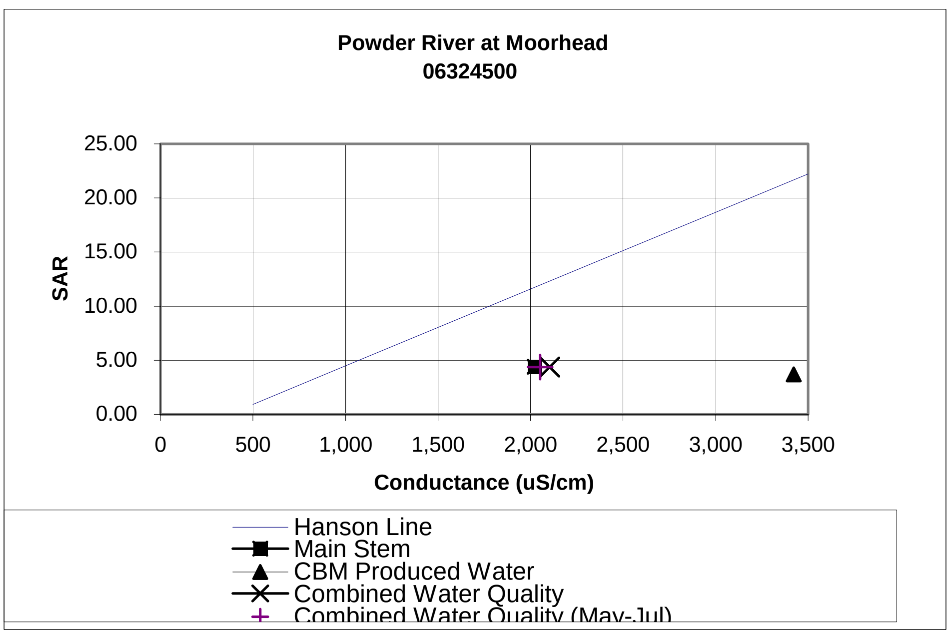


Figure 4–35 Projected Effects of Salinity and SAR on Infiltration over Project Life – Middle Powder River Sub-Watershed

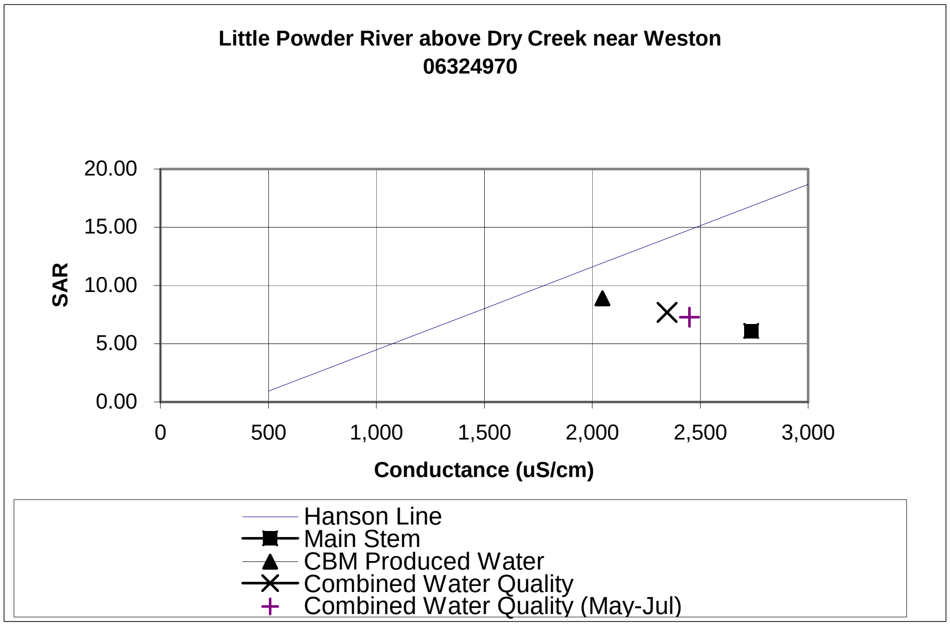


Figure 4–36 Projected Effects of Salinity and SAR on Infiltration over Project Life – Little Powder River Sub-Watershed

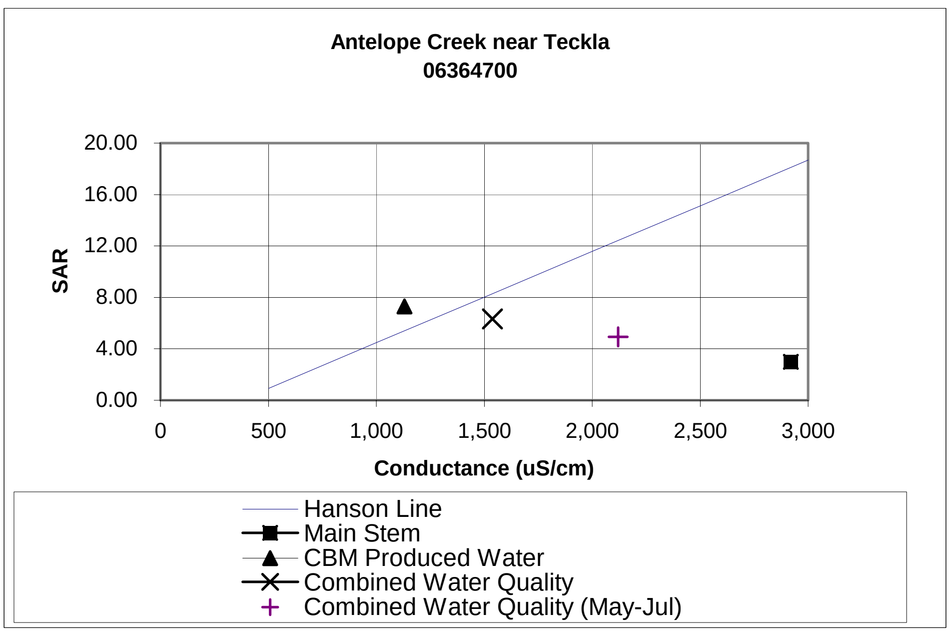


Figure 4–37 Projected Effects of Salinity and SAR on Infiltration over Project Life – Antelope Creek Sub-Watershed

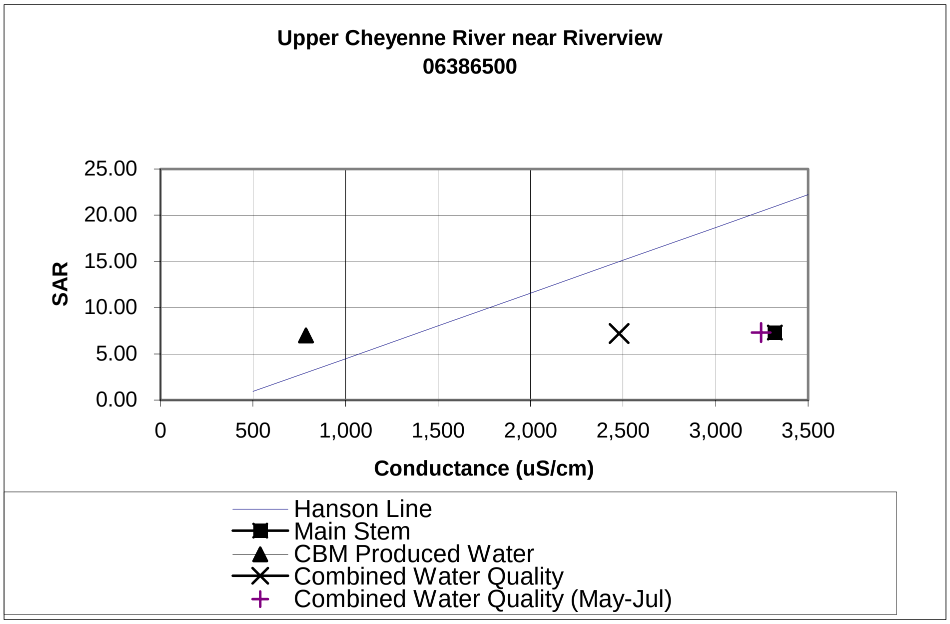


Figure 4–38 Projected Effects of Salinity and SAR on Infiltration over Project Life –Upper Cheyenne River Sub-Watershed

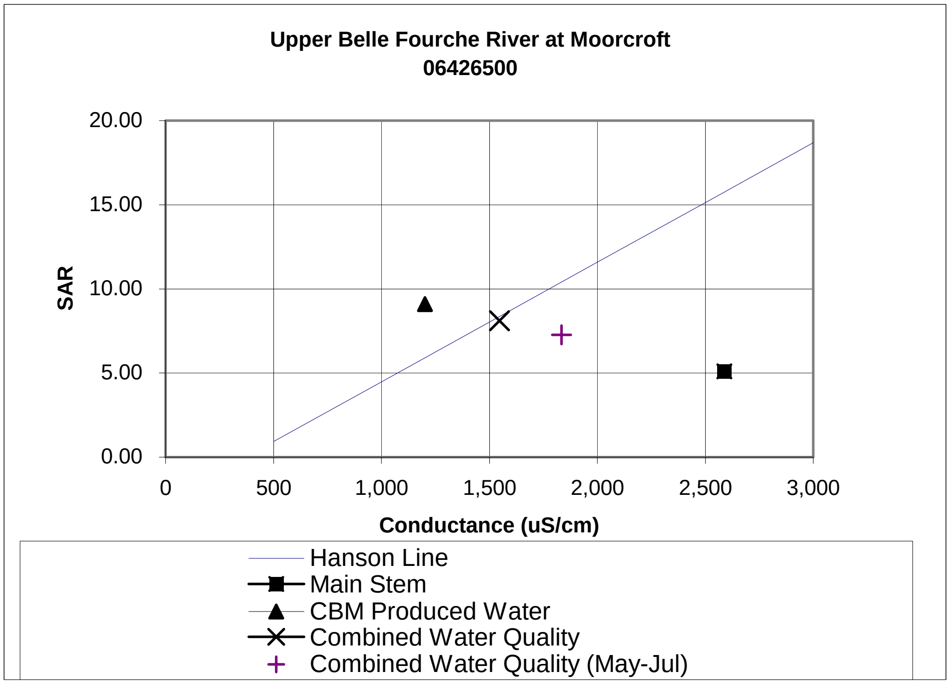


Figure 4–39 Projected Effects of Salinity and SAR on Infiltration over Project Life –Upper Belle Fourche River Sub-Watershed

Surface Drainages

Surface drainages may be affected by the discharge of CBM produced water where channels are not stable, armored, or large enough to accommodate anticipated flows. Localized flooding may occur with increased frequency and magnitude where channel or basin capacity is insufficient to handle increased flows. In contrast to naturally occurring flows, which fluctuate drastically with changing seasons, CBM generated flows occur year-round with small fluctuations. Water management plans would be an integral part of the mitigation planning to control, monitor, and provide for appropriate beneficial use of CBM produced water in an area.

Conveyance losses due to evapotranspiration and infiltration would reduce the volume of discharged CBM produced water by an estimated 80 percent, making it unlikely that most discharged water would reach the main stems of surface drainages (Meyer 2000, AHA 2001b). Although most of the discharged water in an area likely would not reach a main stem drainage, previously ephemeral draws could become perennial downstream from clustered outfalls, where large volumes of CBM produced water are released to surface drainages.

High seasonal flows during the spring would be expected to rise with the addition of CBM produced water. Channels may overbank during snowmelt, flooding nearby fields. Localized erosion and gully formation, water-damaged structures, inundated vegetation, siltation, or breaching of irrigation structures may result from large, late, or prolonged flood events. However, numerous impoundments constructed to store CBM produced water for beneficial use also would serve as effective flood control structures. Increased surface flows also could fill channels and culverts with ice during the winter, causing localized flooding. Closed basins or playas (old lakebeds) may become inundated if CBM produced water is discharged into them.

In-channel impoundments would be designed as flow-through structures and would be properly permitted by the WSEO. No existing surface water right would be expected to be affected by this water handling method. Water discharged to surface drainages would be available for appropriation and diversion, under WSEO authorizations.

Downcutting (stream erosion) and sediment deposition (aggradation) are natural processes that occur as stream drainages age through time. Downcutting occurs within the upper reaches of a drainage system, as the stream channel becomes incised through erosion, until the slope of the stream and its velocity are reduced and further erosion is limited. Sediment deposition occurs within the lower, slower reaches of a stream.

Degradation of surface drainages could result from stream erosion caused by increased surface flows, unless CBM discharge rates and outfall locations are carefully controlled. Increased flows could cause downcutting in fluvial environments, resulting in increased channel capacity within upper and middle reaches of watersheds over time. Where downcutting occurs in highly erodible soils, ravines or gullies are likely to develop unless outfalls are carefully located and designed. Design should incorporate avoidance of surface discharge above existing headcut areas.

Sediment transported downstream from outfalls likely would be deposited in fluvial settings, as stream gradients decrease within lower reaches of drainages. Wherever sediment deposition occurs, channel capacity likely would decrease over time, possibly increasing the likelihood that localized flooding may occur. A new balance between channel capacity and floodplain morphology would be established as the proposed Project is implemented, and would be re-established at the end of the Project's life. Where the quality of produced water and landowner preferences allow the construction of stock reservoirs to store some surface flows for beneficial use, these structures likely also would serve as effective flood control measures during intense storm events. These impoundments would be located in-channel or near-channel and would be designed as flow through structures.

Overbank deposits (produced during flood events) can yield nutrient-rich and arable soils, which may enhance the agricultural uses of the affected lands. Alternatively, overbank deposits may add saline or fine-grained sediments to a floodplain, decreasing productivity and lowering infiltration rates through the addition of materials having elevated SAR values. The latter could occur in watersheds affected by saline soils, soils developed from shales, or CBM produced water containing elevated SAR values.

While drainages would not be expected to flow under completely natural conditions during the life of the Project, the enhanced CBM flows would not be expected to alter surface drainage patterns, except as noted. Streams enhanced by large volumes of CBM produced water may begin to establish meander patterns on longer wavelengths in response to increased flows. At the end of the Project's life, stream drainages would readjust to their existing natural flows.

Springs

New springs may develop in areas where the infiltration of CBM produced water is recharging alluvial aquifers or Wasatch sands. If compaction occurs during construction or production activities, spring flow may be inhibited locally. Natural discharge from springs potentially can be affected by a reduction in hydraulic head within the source aquifer. Potential effects on springs should be analyzed site-specifically, as needed, during the review of APDs or Sundry Notices, and impacts mitigated through the application of special conditions of approval. Additional discussion is in the groundwater section (beginning on page 4–1.

Water Bodies

Two large reservoirs located within the Project Area (Lake DeSmet in the Clear Creek sub-watershed and Keyhole Reservoir in the Upper Belle Fourche River sub-watershed) potentially would receive surface flows containing CBM produced water. More than half of the smaller 1,161 permitted surface water impoundments in the Project Area would also potentially receive surface flows containing CBM produced water. Concentrations of trace metals and salts in the impounded water may become elevated as evaporation occurs. Water quality could reach levels of concern for various constituents when inflow to the impoundments cease, and prior to reclamation. Evaporation of pond contents with no additional inflow of CBM water could be expected to elevate constituent concentrations by as much as 20 percent each year until the contents are dry. The water chemistry, sediment load, and flow quantity of CBM produced water that may reach surface water impoundments should be carefully monitored and addressed in water management planning for each area affected by CBM development. Potential effects on surface water impoundments should be analyzed site-specifically, as needed, during the review of APDs or Sundry Notices, and impacts mitigated through the application of special conditions of approval.

Surface Water Use

Produced water from CBM wells is most likely to be used for livestock watering, fisheries, and irrigation. Dust abatement of county roads is likely to be accomplished using CBM water in minimal amounts. Surface water withdrawals in the Project Area totaled 1,636 mgd in 1995 (USGS 1995). The total volume of water that would be produced during the life of the Project is estimated to be 4.4 million acre-feet. Conveyance losses of 80 percent due to evapotranspiration and infiltration along stream channels would result in approximately 476,000 acre-feet of CBM produced water available for withdrawal over the life of the Project.

Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences resulting from changes in the distribution of water handling options (discussed below), the effects on surface water resources would be similar to those described under Alternative 1.

The distribution of water handling methods under Alternative 2A is summarized in Table 2-9. The percentage of water handled by each of these options as a percentage of the total water production is summarized on Table 4–2. Alternative 2A emphasizes discharge of CBM water to infiltration impoundments, accounting for 20 to 40 percent of the total water production. The maximum water volume discharged to the surface under Alternative 2A is expected to increase from an estimated 66,000 acre-feet in 2002, to an estimated 83,000 acre-feet, occurring in 2006. The volume of CBM water discharged to surface drainages is less than under Alternative 1. There would be no surface discharge in the Salt Creek sub-watershed. The projected annual outflow of CBM produced water at the sub-watershed boundaries also would be less than under Alternative 1, as shown on Table 4–1.

CBM supplemented flows at the sub-watershed boundaries would account for between 0.2 and 13 percent of the annual average stream flows, as shown on Table 4–2. CBM supplemented flows at the sub-watershed boundaries would be less than under Alternative 1 in all sub-watersheds except the Upper Belle Fourche River sub-watershed, which would remain unchanged from Alternative 1.

Water quality of the receiving streams may improve because of the increased use of passive treatment of CBM water prior to surface discharge. The water quality of the receiving streams is likely to remain suitable for irrigation purposes. The volume of CBM water likely to be used for irrigation, livestock watering, and other beneficial uses would be less than under Alternative 1, with approximately 179,000 acre-feet available for use over the life of the project.

Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Except for the differences resulting from changes in the distribution of water handling options (discussed below), the effects on surface water resources would be similar to those described under Alternative 1.

The distribution of water handling methods under Alternative 2B is summarized in Table 2–9. The percentage of water handled by each of these options as a percentage of the total water production is summarized on Table 4–3. Alternative 2B emphasizes treatment, both passive and active, prior to surface discharge of CBM water. The maximum water volume discharged to the surface under Alternative 2B is expected to increase from an estimated 107,000 acre-feet in 2002, to an estimated 146,000 acre-feet, occurring in 2006. The volume of CBM water discharged to surface drainages would be less than under Alternative 1, but more than under Alternative 2B. There would be no surface discharge in the Salt Creek sub-watershed. The projected annual outflow of CBM produced water at the sub-watershed boundaries also would be less than Alternative 1, but would be more than under Alternative 2A, as shown on Table 4–1.

CBM supplemented flows at the sub-watershed boundaries would account for between 0.1 and 14 percent of the annual average stream flows, as shown on Table 4–3. CBM supplemented flows at the sub-watershed boundaries would decrease from Alternative 1 in all sub-watersheds except the Upper Belle Fourche River sub-watershed, which would increase from Alternative 1.

Water quality of the receiving streams would likely improve and increase assimilative capacity because of the increased use of treatment of CBM water prior to surface discharge. The water quality of the receiving streams would likely remain suitable for irrigation purposes. The volume of CBM water likely to be used for irrigation, livestock watering, and other beneficial uses would be less than under Alternative 1, but more than under Alternative 2A, with approximately 271,000 acre-feet available for use over the life of the Project. It is likely that consumptive use of CBM water would increase as the water would be of higher quality due to the treatment methods employed prior to discharge.

Alternative 3

Alternative 3 (No Action) assumes that no new Federal wells would be completed, except for potential drainage situations. This would result in a substantial reduction in projected new CBM wells, from 39,367 to 15,458. Except for the differences discussed below, the effects on surface water resources would be similar to those described under Alternative 1.

The maximum water volume discharged to the surface under Alternative 3 is expected to increase from an estimated 36,000 ac-ft in 2002, to an estimated 112,000 ac-ft, occurring in 2007. The volume of CBM water discharged to surface drainages would be less than under Alternative 1. The projected annual outflow of CBM produced water at the sub-watershed boundaries also would be less than Alternative 1, as shown on Table 4–1.

CBM supplemented flows at the sub-watershed boundaries would account for between 0.02 and 6 percent of the annual average stream flows, as shown on Table 4–3. CBM supplemented flows at the sub-watershed boundaries would be less than under Alternative 1 in all sub-watersheds except the Salt Creek sub-watershed, which would remain unchanged from Alternative 1.

The water quality of the receiving streams would likely remain suitable for irrigation purposes. The volume of CBM water likely to be used for irrigation, livestock watering, and other beneficial uses would decrease under Alternative 3, with approximately 182,000 acre-feet available for use over the life of the Project.

Cumulative Effects

Alternative 1

Surface Water Quantity

The cumulative surface water flows at the Project Area boundaries are shown in Table 4–7. CBM-enhanced surface flows from the following sub-watersheds would be combined, as outflow from the Powder River at the Montana State line: Salt Creek; Upper Powder River; Crazy Woman Creek; Clear Creek, and Middle Powder River. CBM-enhanced surface flows from the following sub-watersheds would not be combined with any other sub-watersheds, and each would represent a separate outflow at the Montana State line: Upper Tongue River and Little Powder River. CBM-enhanced surface flows from the Upper Belle Fourche River sub-watershed would not be combined with any other sub-watersheds, and would represent a separate outflow at the eastern Project Area boundary. CBM-enhanced surface flows from the following sub-watersheds would be combined, as outflow from the Cheyenne River at the eastern Project Area boundary: Antelope Creek; and Upper Cheyenne River.

Active coal mines would have additional surface water to manage. Active coal mines are located within three sub-watersheds in the Project Area: the Upper Belle Fourche River, Little Powder River, and Upper Cheyenne River sub-watersheds. Culverts carrying water from upstream reaches of watersheds undergoing CBM development may have to be re-sized. Diversion channels for natural flows may have to be re-sized to handle additional flows. Mining operations that partially treat water in their sedimentation impoundments may have additional water to treat. In these situations, the water quality at the mines' NPDES outfalls may be affected by commingling CBM discharge waters with those from the surface mines. Potential effects on mine operations should be analyzed site-specifically, as needed, during the review of CBM Plans of Development and/or Water Management Plans, and impacts mitigated through

Water Management Plans, and impacts mitigated through the application of special conditions of approval for affected APDs.

Table 4–7 Cumulative Surface Water Volume and Flow at Project Boundary

Sub-Watershed	Cumulative CBM Enhanced Surface Water Volume at Project Boundary (acre-feet)	Cumulative CBM Enhanced Surface Water Flow at Project Boundary (cfs)
Alternative 1		
Upper Tongue River at State Line near Decker, WY	51,210	71
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	370,923	512
Little Powder River above Dry C near Weston, WY	15,581	22
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	17,323	24
Upper Belle Fourche River below Moorcroft, WY	43,550	60
Alternative 2A		
Upper Tongue River at State Line near Decker, WY	14,632	20
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	113,203	156
Little Powder River above Dry C near Weston, WY	5,993	8.3
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	12,598	17
Upper Belle Fourche River below Moorcroft, WY	43,550	60
Alternative 2B		
Upper Tongue River at State Line near Decker, WY	38,407	53
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	177,341	245
Little Powder River above Dry C near Weston, WY	8,629	12
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	12,598	17
Upper Belle Fourche River below Moorcroft, WY	48,389	67
Alternative 3		
Upper Tongue River at State Line near Decker, WY	21,894	30
Upper Powder River at Arvada, WY		
Salt Creek near Sussex, WY		
Crazy Woman Creek at Upper Station near Arvada, WY		
Clear Creek nr Arvada, WY		
Middle Powder River at Moorhead, MT	163,396	226
Little Powder River above Dry C near Weston, WY	16,265	23
Antelope Creek near Teckla, WY		
Upper Cheyenne River near Riverview	10,339	14
Upper Belle Fourche River below Moorcroft, WY	35,516	49

Surface Water Quality

The cumulative impacts on surface water resources from activities associated with CBM development and surface coal mining activities are considered in mass balance calculations of CBM and mine surface discharge from each subwatershed and existing water quality and flow data. The calculations were performed to provide an estimate of the cumulative effects on salinity and SAR expected at the Project boundary. Mass balance calculations were performed using the same methodology described earlier in this section for Project-only impacts, with the following exceptions. WDEQ files indicate that coal mine discharges do not occur regularly. Typically, coal mine discharges occur only in response to large storm events, when sedimentation ponds require dewatering. Discharge monitoring reports do not contain parameters needed to evaluate salinity or SAR for mine discharge waters. TDS values in the sedimentation ponds from surface coal mines were available for a few mines from on-site inspection records. TDS values of these sedimentation ponds average 1,500 mg/L in the Upper Belle Fourche sub-watershed, 1,600 mg/L in the Upper Cheyenne River sub-watershed, and 2,950 mg/L in the Little Powder River sub-watershed. Since the water being discharged by the mines has been extracted from the coal aquifer, it is likely that the representative coal aquifer water quality data in Table 3-2 would represent the salinity and SAR of the mine discharge waters, even though mine water that is discharged in response to storm events is likely to show the effects of mixing with precipitation and sediment from the mine area. Since discharges of CBM water are relatively constant, it is likely that the intermittent surface discharge from coal mining activities would not cause any discernible effects in water quality, with respect to CBM discharges.

Cumulative effects analyzed in the Powder River at Moorhead, Montana for the Salt Creek, Upper Powder River, Crazy Woman Creek, Clear Creek, and Middle Powder River sub-watersheds are represented in Figure 4–40. Cumulative effects analyzed in the Cheyenne River at Riverview, Wyoming for the Upper Cheyenne River and Antelope Creek sub-watersheds are represented in Figure 4–41. Cumulative effects in the Upper Tongue River sub-watershed, the Little Powder River sub-watershed, and the Upper Belle Fourche River sub-watershed would be represented by Figure 4–40 and Figure 4–41, shown previously, as effects would be similar to those projected over the life of the project. Although it was possible to make calculations that would be reasonably representative of the cumulative effects at the Project boundaries, it is not reasonable to project that the assumptions utilized would apply over the life of the Project. Insufficient data are available to compile cumulative water quality data at the Project boundaries. For this reason, the State of Wyoming established a tributary monitoring program in 2001 to collect data from locations where it is needed for meaningful analysis of water quality at the State line. The States of Montana and Wyoming also have agreed to an interim Memorandum of Cooperation MOC) to document their commitments and intent to protect and maintain water quality conditions at the State line. This interstate agreement will include a monitoring program that would provide additional data for evaluating cumulative effects on water quality.

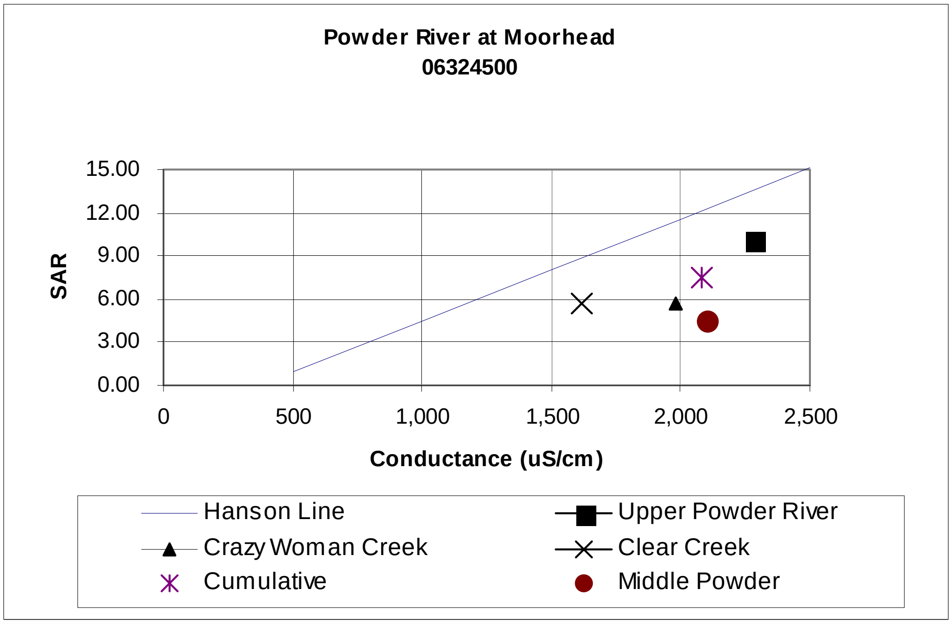


Figure 4–40 Projected Cumulative Effects of Salinity and SAR on Infiltration – Powder River at Moorhead, Montana

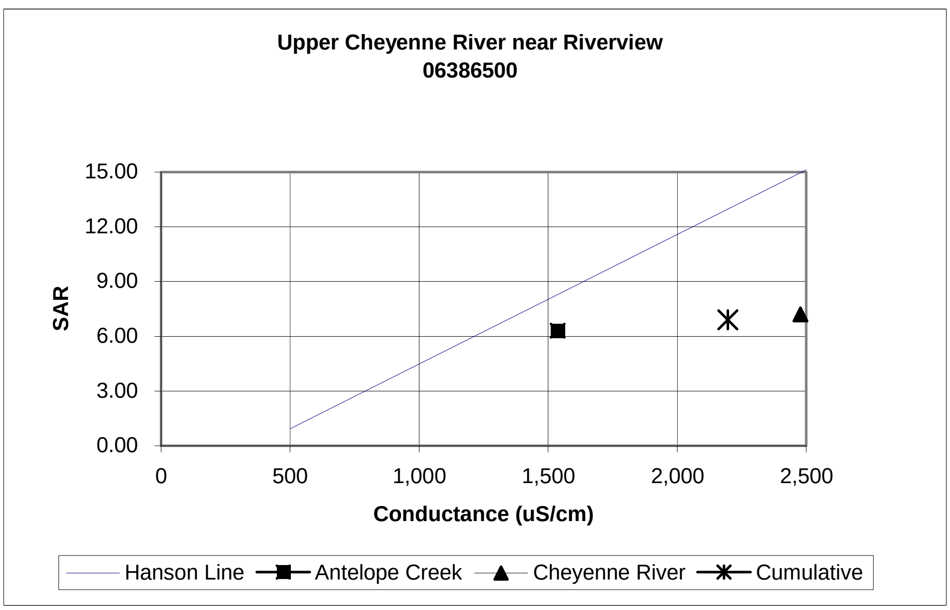


Figure 4–41 Projected Cumulative Effects of Salinity and SAR on Infiltration – Cheyenne River at Riverview, Wyoming

Surface Drainages

By the end of the Project's life, some surface drainages within the Project Area may be slightly deeper than they are today due to stream erosion. Careful siting and design of surface discharge outfalls would prevent or mitigate this impact. Downvalley, a careful observer may feel that there may be a few more bar or beach deposits within perennial streams or rivers than there are today. Spring flows may have changed from present conditions. Potential effects on existing springs should be analyzed site-specifically, as needed, during the review of CBM Plans of Development and/or Water Management Plans, and impacts mitigated through the application of special conditions of approval for affected APDs.

Water Bodies

Reservoirs downstream of the Project Area likely would receive more water and could receive more sediment as a consequence of CBM development. Current protocols for managing these reservoirs may need to be revised. Additional water may be available to support adjudicated water uses downstream of the reservoirs.

Water Use

Agricultural and livestock operations would have additional surface water to manage and use during the life of the Project. Stock watering and irrigation likely would increase within the Project Area. Groundwater withdrawals for these purposes would likely decrease due to the increased availability of surface water.

Alternative 2A

The cumulative effects on surface water resources would be similar to those described under Alternative 1, except as noted below.

Cumulatively, CBM-enhanced surface flows at the Project Area boundaries would be less than under Alternative 1.

Surface water quality at the Project Area boundary would likely be of better quality than under Alternative 1. The volume of CBM-enhanced surface waters likely to be used for irrigation, livestock watering, and other beneficial uses also would be less than under Alternative 1.

Alternative 2B

The cumulative effects on surface water resources would be similar to those described under Alternative 1, except as noted below.

Cumulatively, CBM-enhanced surface flows at the Project Area boundaries would be less than under Alternative 1, but more than under Alternative 2A.

Surface water quality at the Project Area boundaries would likely be of better quality than under Alternatives 1 and 2A. The volume of CBM-enhanced surface waters likely to be used for irrigation, livestock watering, and other beneficial uses also would be less than under Alternative 1, but more than under Alternative 2A.

Alternative 3

The cumulative effects on surface water resources would be similar to those described under Alternative 1, except as noted below.

Cumulatively, CBM-enhanced surface flows at the Project Area boundaries would be less than under Alternative 1.

Surface water quality at the Project Area boundaries would likely be of better quality than under Alternative 1. The volume of CBM-enhanced surface waters likely to be used for irrigation, livestock watering, and other beneficial uses also would be less than under Alternative 1.

Physiography, Geology, Paleontology and Mineral Resources

Paleontology

Paleontological resources are fragile resources and, once disturbed, lose much of their preserved information. Avoidance of significant sites is the preferred mitigation of adverse effects on paleontological resources.

Within the Powder River Basin Project Area, the construction of oil and gas-related facilities, including access roads, could adversely impact scientifically significant fossils. The potential for impact to significant fossils is greatest in areas where Class 3, 4, or 5 formations are present. Both surface and subsurface fossils could be damaged or destroyed during ground-disturbing activities. The greatest potential impact to surface and subsurface fossils comes from excavations of surface sediments and shallow bedrock. These types of excavations are commonly associated with well pad, pipeline, access road, and building construction. Drilling activities may impact fossils, but because this impact is not visible, verifiable or preventable, the impact to significant fossils posed by drilling is considered low.

Across the Project Area, occurrences of surface fossils could be rejuvenated at previously collected fossil localities within as little time as one year. In addition, surface fossil concentrations could develop where no fossils were present before wherever fossiliferous rocks are exposed due to erosion.

As part of the APD approval process for Federal lease development, the BLM and FS require surveys of all areas where ground-disturbing activity is proposed when significant paleontological resources are known to occur. In most cases, given the small size bias of Wasatch Formation fossils in the PRB, individual construction sites should be able to be cleared of all significant fossils prior to construction. APD conditions of approval require protection and prompt reporting of paleontological resources discovered during Project activities. Operations must be suspended until an evaluation of the discovery and mitigation are completed. It is unlikely that any fossils discovered during pre-construction surveys or monitoring phases would result in construction delays. In addition to adverse impacts during construction, significant fossils may become exposed during subsequent erosion of freshly excavated rocks at each construction site. In Class 3 or 5 formations, post-construction paleontologic inspections may be recommended, depending upon the results of the pre-construction site survey.

All facilities located on Federal surface ownership lands would be considered Federal undertakings, subject to Federal guidelines and regulations protecting paleontological resources. Where oil or gas development excludes Federal leases or surface ownership lands, no Federal permits are required to develop these lands, and protection measures for paleontological resources might not be mandated by the landowners or monitored as closely.

Alternative 1

Development of oil or gas resources on Federal leases would be considered a Federal undertaking, subject to Federal guidelines and regulations protecting paleontological resources. However, only a portion of the facilities associated with Fee and State wells developed under Alternative 1 are likely to be located on Federal surface ownership lands and would be considered Federal undertakings.

Surface disturbance associated with construction activities would increase the potential for paleontological resources to be affected. Only portions of the Project Area have been evaluated for the occurrence of paleontological resources. As a result, no accurate estimate can be made of the number of paleontological sites that may be affected based on the 156 localities that have been recorded.

Surface disturbance typically associated with CBM development in the Project Area, i.e., use of two-track roads and natural terrain without vegetation removal and drill pads or pipelines requiring minimal cut-and-fill excavations, would limit the effect of ground-disturbing activities on subsurface paleontological resources. Although paleontological resources contained in near-surface horizons of soil and surficial deposits likely already have been disturbed by natural processes or human activity, there could be additional disturbance to paleontological resources. Access across natural terrain without vegetation removal and limited use of shallow excavations likely would have minimal additional effect on these resources. Surface use and shallow excavations likely would have little or no effect on undisturbed paleontological resources occurring below the surface.

Where Federal undertakings associated with oil or gas development are involved, potential effects on paleontological resources would be analyzed site-specifically, as needed, during review of APDs, Sundry Notices, ROWs, or Special Use Permits, and effects eliminated or minimized through the application of special conditions of approval for operations. Where direct effects cannot be avoided, an approved data recovery plan would be developed to mitigate the adverse effects.

The development of Fee and State wells would not be considered Federal undertakings, and would not be subject to Federal guidelines and regulations protecting paleontological resources. Unprotected paleontological resources potentially could be disturbed, damaged, destroyed, or removed from the site, losing much or all of their preserved scientific information.

Alternative 2

Effects on paleontological resources likely would be similar to those described under Alternative 1.

Alternative 3

Under Alternative 3, additional development of Federal leases would not be authorized once existing authorizations under the Wyodak CBM Project EIS and the Wyodak Drainage CBM EA have been exhausted. Oil or gas development of Fee and State leases under Alternative 3 would involve far fewer Federal undertakings subject to Federal guidelines and regulations protecting paleontological resources than Alternatives 1 or 2. Consequently, the number of paleontological resources likely to be impacted would be fewer.

Only a portion of the facilities associated with Fee and State wells developed under Alternative 3 are likely to be located on Federal surface ownership lands and would be considered Federal undertakings. Where oil or gas development involves Federal surface ownership lands, effects on paleontological resources likely would be similar to those described under Alternatives 1 and 2.

The development of Fee and State wells under Alternative 3 would not be considered a Federal undertaking, and would not be subject to Federal guidelines and regulations protecting paleontological resources. Unprotected paleontological resources potentially could be disturbed, damaged, destroyed, or removed, losing much or all of their preserved scientific information.

Mineral and Energy Resources

Alternative 1

Methane would be produced from Federal, State, and Fee CBM wells drilled into underlying coal seams in the Project Area. Based on an average production rate of approximately 160,000 cubic feet of CBM per well per day following initial dewatering, and an average of 400 million cubic feet of CBM available per well (De Bruin et al. 2001), an estimated 16 trillion cubic feet of methane would be produced from the CBM wells included in Alternative 1, over the life of those wells. Initial production rates during the first few years of production are expected to be higher, and then steadily decline during the rest of the well's economic life.

CBM development in the PRB has been concentrated on Fee and State leases for several years, causing drainage of CBM resources from Federal leases. Drainage of CBM resources from Federal lease areas would continue to occur under Alternative 1, as development of Federal leases likely would continue to lag behind the development of Fee and State leases. CBM development on Federal leases in some extensively drained areas may no longer be economically feasible. The BLM is continuing to analyze the ongoing and anticipated levels of drainage within the Project Area.

Oil and gas would be produced from non-CBM wells drilled into underlying geologic formations or structures in the Project Area. For the purpose of this analysis, the following assumptions made by the BLM (BLM 2001f) have been used to develop an estimation of the anticipated production of oil and gas from non-CBM wells. Based on a mix of oil and gas discoveries (80 percent of new fields discovered would contain oil and 20 percent of new fields discovered would contain gas), the expected success ratio for the 3,200 new exploratory wells drilled (15 percent), the anticipated number of productive wells (480), the average life of a productive well (15 years), average production of 137,800 barrels of oil equivalent (BOE) over the life of each productive well, and the anticipated average size of new fields (5 wells), an estimated 66,144,000 BOE would be produced from the non-CBM wells included in Alternative 1.

Past conflicts in the Project Area between CBM development and expanding surface coal mining operations indicate potential conflicts may arise. BLM stipulations mandating specific timing of activities or precluding CBM development from some mine areas would be applied unless potential conflicts are resolved through sponsored cooperation among affected interests that would result in mutual agreements for affected areas.

CBM development occurring upstream of nearby surface coal mines could affect coal mining operations. CBM produced water discharged upstream of mines could increase surface flows in the vicinity of coal operations or decrease the rate of groundwater withdrawals currently accompanying ongoing coal mining operations. Changed conditions could affect the design or permitting of coal mining operations and the mining schedule for specific areas.

Sediment control structures located in the coal mine permit areas likely would be affected by increased surface flows anticipated under Alternative 1. These structures have been designed to accommodate historical flow rates that do not include contributions from CBM generated flows. Some design aspects of mining operations may need to be changed. Any required revisions to approved mine plans would impact operators and agencies involved in reviewing proposed changes. Timeframes needed to change design aspects of mining operations may affect the timeframes for initiation of CBM discharges. CBM generated flows are not likely to be lower quality (i.e., have elevated TDS over existing flows). The effects on the availability of groundwater for mining operations and the effects of increased surface flows on mine facilities could be mitigated site-specifically through cooperative agreements among CBM developers and mine operators, as potential effects are identified.

Water production rates, conveyance losses, water chemistry, and water handling methods and their effects have been estimated for sub-watersheds containing surface coal mines. This additional discussion occurs in the surface water section of this chapter. To assist the reader in following this discussion, the relative locations of sub-watersheds, surface coal mines, existing and projected CBM wells, and existing water wells are shown on Figure 2–1.

Although conflicts between CBM drilling and existing or potential surface coal mining may occur, the economic value of the coal resource would not be affected. Development of CBM wells would be precluded in areas of active or impending coal mining. Coal mining before CBM development would result in valuable CBM resources and royalties not being recovered from the mined area.

Locating CBM wells in areas where future mining may take place would preclude mining during the life of CBM wells located in the proposed mining area. Coal in these areas could be mined after CBM extraction is completed or terminated, or after an agreement is negotiated between the CBM developers and the coal mine operators. The effects on mining schedules could be mitigated site-specifically through cooperative agreements among CBM developers and mine operators, as potential effects are identified.

Subsurface uranium deposits located in the southwestern portion of the Project Area are associated with Wasatch Formation sandstones. Withdrawal of CBM and water from the stratigraphically lower Fort Union Formation would not be likely to affect the potential recovery of uranium resources from in-situ (in place) subsurface leaching of sandstones. However, if infiltration of sulfate-rich water into mining areas were to occur, uranium might precipitate prematurely, decreasing recovery rates.

CBM development under Alternative 1 would not be likely to affect the recovery of other mineral resources occurring in the Project Area. Oil and gas have been produced from geologic formations occurring several thousand feet below the coal zone. Salable minerals, primarily clinker, sand, and gravel, are produced from surface deposits. Bentonite, high-calcium limestone, and gypsum occurring in rocks exposed along the uplifted margins of the study, are stratigraphically below the geologic formations that may be affected by CBM development in the PRB. No other locatable mineral deposits are known to exist in the Project Area. Development of existing mineral rights in the Project Area would be based on existing claims, lease terms and agreements; future conflicts would be dealt with on a case-by-case basis.

Alternative 2

Effects on mineral and energy resources likely would be similar to those described under Alternative 1.

Alternative 3

Effects on mineral and energy resources likely would be similar to those described under Alternative 1; however the exclusion of Federal wells and the overall reduced number of CBM wells under Alternative 3 would result in some variations from the effects described under Alternative 1. The magnitude of the effects on mineral and energy resources under Alternative 3 likely would be reduced. Drainage of CBM resources likely would be greater under Alternative 3, as more new drainage situations would be created by the exclusion of Federal wells from projected activities.

Geologic Hazards

Potential effects, such as creating geologic hazards, are not likely to occur. As part of the APD approval process for Federal lease development, BLM, and FS when involved, require consideration of geologic hazards contained in all areas where ground-disturbing activity is proposed. APD conditions of approval would require mitigation of effects.

All facilities located on Federal surface ownership lands would be considered Federal undertakings, subject to Federal guidelines and regulations for environmental protection. Where oil or gas development excludes Federal leases or surface ownership lands, no Federal permits are required to develop these lands, and protection measures for geologic hazards might not be mandated by the landowners or monitored as closely.

Alternative 1

In portions of the Project Area where underground injection would be used as one of the methods of handling the water produced by CBM wells, no excessive build-up of rock pressure or fracturing of rocks that could cause an earthquake to occur would be anticipated during injection activities. Therefore, no earthquakes associated with underground injection would be expected to occur. Use of underground injection to dispose of produced water would occur in accordance with Federal and State regulatory requirements. Injection wells would be authorized only where the injection zone is sufficiently porous and permeable that fluids could enter the rock formation without causing an excessive build-up of pressure or fracturing of rocks.

Anticipated CBM flows could increase the frequency or magnitude of flooding anticipated in the Project Area. Minimization of flood hazards within the Project Area would be dependent upon the use of mitigating measures to ensure adequate control of anticipated surface flows and design of impoundments. Comprehensive water management planning, including development and implementation of best management practices for discharge outfalls and water development structures, would mitigate the effects of anticipated CBM flows. However, when lower than anticipated flood damage occurred during an intense storm near Gillette in May 2000, this event demonstrated that management of existing CBM flows, including construction of many small reservoirs, reduced the severity of flooding in the Project Area in one case.

Surface disturbance could worsen existing landslide hazards in the Project Area, and could cause new landslide hazards. Unless disturbance to existing landslides and areas susceptible to movement, such as steep slopes or unstable soils, is avoided or mitigated during oil or gas development, mass movements likely would increase within the Project Area, causing resource and property damage. Landslides could be activated during oil or gas development activities, however, design of operations incorporating best management practices and mitigation measures that minimize landslide risks would lessen the potential that landslides would increase within the Project Area.

Surface disturbance could cause or worsen the continuing migration of windblown sand deposits occurring along the southeastern and eastern margins of the

PRB, unless disturbed areas are stabilized promptly with vegetative cover. Continuing migration of windblown deposits would contribute to soil loss, if existing soils were blown away with sands. Increased sedimentation in surface drainages also would result from the migration of sand deposits.

CBM development would not be likely to cause noticeable ground subsidence, aquifer compression, or aquifer collapse in the Project Area. Where unconsolidated alluvial aquifers have collapsed in other geographic areas due to dewatering, significant ground subsidence has occurred. However, the Fort Union Formation is a consolidated rock unit and is not as susceptible to aquifer compression or collapse as an unconsolidated unit. Also, based on its estimated storage coefficient, and recognized depth from the surface to the coal zone aquifer where decline in the hydraulic head could occur, the Fort Union Formation could not be dewatered enough to cause noticeable ground subsidence.

Case et al. (2000) describe the formula used to calculate the amount of aquifer compression that occurs when water is withdrawn from an aquifer. The change in aquifer thickness is equal to the storage coefficient times the change in head. The storage coefficient is determined through a pump test and the change in head is observed (or monitored) over time as declines in water level.

The storage coefficient used by Case et al. (2000) for PRB producing coals and underlying sands (1.0×10^{-4}), represents the best estimate available for the storage coefficient applicable to the Fort Union Formation. Since the Big George coal zone occurs between 1,000 and 2,000 feet below the surface in the central portion of the PRB, a theoretical drawdown to the top of the Big George coal zone could be up to 2,000 feet in the central portion of the PRB. Applying the formula described above allows consideration of the largest aquifer compression theoretically possible in the central portion of the PRB. It should be noted that a decline in hydraulic head to the top of the Big George coal zone is not projected in this analysis of the environmental effects under Alternative 1.

Aquifer compression in the central portion of the PRB theoretically could be 2.4 inches, if the hydraulic head in the Fort Union Formation declined to the top of the Big George coal zone, although a decline of this magnitude is not projected under Alternative 1. Since the compressibility of an aquifer decreases with increasing depth, (Edgar and Case 2000), CBM development of deeper coals, such as the Big George zone, likely would result in less actual aquifer compression than is calculated above. In addition, the entire aquifer compression likely would not be transmitted to the surface, resulting in no noticeable ground subsidence even under maximum theoretical drawdown. The effects of aquifer compression under Alternative 1 would be even less, and would not be noticeable.

Gas migration, seepage, and venting are naturally occurring processes where coal beds are extremely close to the surface, and can be enhanced during CBM development activities. Methane migration or seepage could occur within the PRB as CBM development proceeds. Conditions for methane release would depend on site-specific geologic conditions and/or the specific well development conditions that remain after construction. Methane could emerge from water wells near CBM production areas, affecting stock and residential wells. The escape of methane also can result from inadequate well control procedures or faulty well casing or plugging. Methane would be controlled through BLM mandated APD conditions of approval addressing well control, casing, ventilation, and plugging procedures appropriate to site-specific CBM development plans.

CBM development is not likely to increase the occurrence of underground coal fires in the Project Area. CBM development in the PRB, including development under Alternative 1, is occurring under confined conditions in the coal aquifer, which are not associated with spontaneous fires. The partial removal of water from the coal seam during CBM development depressurizes the coal seam, and reduces hydraulic head, but is not likely to leave the coal seam in a condition where oxygen would replace water in the coal seam and result in spontaneous combustion. The conditions established and maintained in CBM wells during drilling and after well completion in order to meet health and safety requirements and optimize gas production, also create unfavorable conditions for the spontaneous combustion of coal. Wellbore conditions are controlled to ensure airflow out of the well, flushing of fines from the well, and venting of heat at the surface.

Alternative 2

Effects associated with geologic hazards likely would be similar to those described under Alternative 1.

Alternative 3

Under Alternative 3, additional development of Federal leases (other than Federal protective wells in drainage situations) would not be authorized once existing authorizations under the Wyodak CBM Project EIS and the Wyodak Drainage CBM EA have been exhausted. Effects associated with geologic hazards likely would be similar to those described under Alternative 1, although oil or gas development of Fee and State leases under Alternative 3 would involve far fewer Federal undertakings than Alternatives 1 or 2, and less Federal control of CBM development activities in geologic hazard areas.

Soils

Short-term effects associated with construction activities consist of construction of roads, well pads and production facilities, water handling facilities, erection of overhead electric lines, and burial of water and gas pipelines and electric lines. Disturbances related to the burial of pipelines and electric lines would not occur in the long-term as the trenches would be reclaimed upon completion. Because most of the well pad is not needed for production, a majority of the disturbance associated with well pad construction would consist of short-term disturbance.

Long-term effects include the disturbance of soils for roads, reduced well pads and production facilities, water handling facilities, and overhead electric lines. All facilities under long-term effects are necessary for production of CBM gas or water management.

Effects to soils result from the clearing of vegetation, excavation, stockpiling and redistribution of soils during reclamation and construction activities, compaction, and the storage or discharge of produced water. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation for facility pads and roads could cause slope steepening in cut and fill areas, mixing of soil layers, and the breakdown of soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and a loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. Depending on the infiltration rates, storage or discharge of produced water could alter physical and chemical properties of soils. All these effects could alter the soil's resistance to water and wind erosion and response to reclamation.

While the discussions in this section are adequate for a general level of analysis, it is insufficient for use in locating specific well pads, access roads, pipelines, and other associated facilities. Site-specific analysis, typically done during the APD process, would identify particular soil concerns and appropriate mitigation measures. The Buffalo Field Office Coal Bed Methane Well APD and Project Planning Guide (October 2000) provides guidelines for this analysis.

Alternative 1

In all, an estimated 211,992 acres of land, or 2.7 percent of the Project Area, may be affected by CBM development activities in the short term. In contrast, approximately 108,779 acres of land, or 1.4 percent of the Project Area, may be affected in the long term. These disturbances would occur on 23 of the 59 soils series that exist in the Project Area. Only soils that would be disturbed by the alternatives will be discussed in this analysis. Together, these soil series make up approximately 75 percent of the Project Area. Table 4–8 breaks down disturbance by sub-watershed and soil type and Table 4–9 lists the disturbance for each type of hazard.

Wind Erosion Hazard

Wind erosion is a concern with soil series WY124, WY126, WY207, WY209, and WY211 located in central and western Converse County and extending from south of Gillette to the Montana-Wyoming state line in Campbell County (Figure 4–42). These series all have one or more major constituent that is a fine sand or sandy loam which can easily be picked up and spread by wind (Appendix F). Approximately 25,474 acres in the short term and 13,403 acres in the long term would be disturbed on soils with high wind erosion potential. Construction activities where vegetation is removed and the soil is exposed and broken up present the greatest threat to soils with wind erosion potential. These activities include cut and fills associated with pad and roads, trenching for pipeline burial, excavation for large reservoirs, and clearing for LADs. COAs should be followed to control wind erosion. Limiting the removal of vegetation, avoiding construction on steep slopes and erosive areas, revegetation or covering any removed and stockpiled topsoil, surfacing roads and pads, and timely reclamation would minimize both short term and long term effects.

Table 4–8 Disturbance by Sub-watershed and Soil Type

		Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
Sub-watershed	Soil Type[1]	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Antelope	*WY125*	13	12	13	13	13	13
	WY129	10,360	4,287	10,619	4,456	10,511	4,382
	WY130	18,203	7,551	18,659	7,848	18,470	7,718
	WY206	467	217	478	225	473	221
	WY207	307	184	315	191	311	188
	WY208	1,056	441	1,082	458	1,071	451
	WY209	2,200	933	2,255	969	2,232	953
	WY210	783	327	803	340	795	334
	WY211	785	335	804	348	796	342
	WY315	13	12	13	13	13	13
	Total	34,185	14,299	35,043	14,861	34,686	14,616
Clear Creek	*WY048*	1,872	990	2,029	1,142	1,917	1,029
	WY049	7,417	4,085	8,035	4,712	7,595	4,248
	WY060	5	6	6	7	5	7
	WY063	21	26	23	30	21	27
	WY065	4,226	2,287	4,578	2,638	4,327	2,378
	WY066	2,199	1,154	2,383	1,331	2,252	1,199
	WY082	69	36	75	42	70	38
	Total	15,810	8,585	17,127	9,903	16,189	8,926
Crazy Woman Creek	*WY048*	869	404	996	534	950	487
	WY049	4,880	2,326	5,593	3,072	5,334	2,803
	WY050	1,112	510	1,275	673	1,216	614
	WY060	9	10	11	13	10	12
	WY063	5	5	5	7	5	6
	WY065	2,051	943	2,351	1,246	2,242	1,137
	WY066	4	2	5	2	4	2
	WY082	5,104	2,418	5,849	3,192	5,578	2,913
	WY087	5	5	5	7	5	6
	Total	14,039	6,624	16,089	8,746	15,343	7,981
Dry Fork Cheyenne	WY203	4	4	4	4	4	4
	WY204	33	30	34	30	34	30
	WY205	4	4	4	4	4	4
	WY206	21	19	21	19	21	19
	WY207	21	19	21	19	21	19
	WY208	8	7	8	8	8	8
	WY209	54	49	55	50	54	49
	WY210	41	37	42	38	42	38
	WY211	17	15	17	15	17	15
	Total	203	183	207	187	205	186
Lightning Creek	WY204	37	34	38	34	38	34
	WY209	112	101	114	103	113	102
	WY210	29	26	30	27	29	27
	WY211	25	22	25	23	25	23
	Total	203	183	207	187	205	186
Little Bighorn	WY057	21	19	21	19	21	19
	Total	21	19	21	19	21	19
Little Missouri	WY002	17	15	17	15	17	15
	WY050	21	19	21	19	21	19
	WY053	352	317	358	324	356	322
	Total	389	351	396	358	394	357
Little Powder	WY002	35	34	37	37	36	35
	WY042	9	8	9	9	9	9
	WY043	13	13	14	14	14	13
	WY044	9	8	9	9	9	9
	WY045	75	71	79	78	77	75
	WY046	61	59	65	64	63	61
	WY047	413	394	435	430	424	412
	WY050	4,200	2,681	4,430	2,923	4,318	2,804
	WY053	2,345	2,237	2,473	2,440	2,410	2,341

Table 4–8 Disturbance by Sub-watershed and Soil Type

		Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
Sub-watershed	Soil Type[1]	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
		1,623	885	1,711	965	1,668	926
	WY125	5,185	2,190	5,468	2,388	5,331	2,291
	WY126	5,770	2,454	6,086	2,676	5,933	2,567
	WY127	2,326	1,704	2,453	1,858	2,391	1,782
	Total	22,063	12,737	23,268	13,891	22,683	13,325
Middle Fork Powder	*WY048*	8	7	8	8	8	8
	WY059	37	34	38	34	38	34
	WY081	8	7	8	8	8	8
	WY084	12	11	13	11	13	11
	WY085	4	4	4	4	4	4
	WY086	8	7	8	8	8	8
	WY088	21	19	21	19	21	19
	Total	99	90	101	91	101	91
Middle North Platte Casper	WY204	8	7	8	8	8	8
	WY205	50	45	51	46	50	46
	WY207	21	19	21	19	21	19
	WY208	33	30	34	30	34	30
	WY209	37	34	38	34	38	34
	WY321	8	7	8	8	8	8
	Total	157	142	160	145	159	144
Middle Powder	WY046	136	143	149	169	143	157
	WY048	12	8	14	10	13	9
	WY049	991	526	1,084	620	1,040	576
	WY050	2,604	1,261	2,847	1,486	2,734	1,380
	WY124	1,312	733	1,434	863	1,377	802
	Total	5,055	2,672	5,527	3,148	5,307	2,924
North Fork Powder	WY059	4	4	4	4	4	4
	Total	4	4	4	4	4	4
Salt Creek	*WY050*	521	215	542	231	539	230
	WY082	339	129	352	138	350	137
	WY085	9	8	9	9	9	9
	WY086	51	48	53	51	53	51
	WY208	9	8	9	9	9	9
	WY211	13	12	13	13	13	13
	WY315	4	4	4	4	4	4
	WY317	13	12	13	13	13	13
	Total	958	435	996	467	990	465
South Fork Powder	WY084	12	11	13	11	13	11
	Total	12	11	13	11	13	11
Upper Belle Fourche	*WY004*	562	322	572	328	563	320
	WY053	357	401	364	409	358	399
	WY115	10	11	10	11	10	11
	WY126	8,208	4,654	8,355	4,748	8,223	4,630
	WY127	1,420	1,194	1,445	1,218	1,422	1,188
	WY128	531	287	541	293	532	285
	WY129	3,441	1,746	3,503	1,781	3,447	1,737
	WY130	13,434	6,913	13,674	7,054	13,458	6,878
	Total	27,965	15,528	28,464	15,843	28,014	15,449
Upper Cheyenne	*WY004*	14	15	15	16	15	16
	WY115	19	20	20	22	19	21
	WY127	19	20	20	22	19	21
	WY129	2,628	1,343	2,748	1,449	2,684	1,390
	WY130	148	82	154	89	151	85
	WY206	34	33	36	36	35	34
	Total	2,862	1,515	2,993	1,634	2,923	1,568
Upper Powder River	*WY048*	3,317	1,649	3,812	2,165	3,661	2,012
	WY049	4,601	2,236	5,288	2,935	5,078	2,727
	WY050	27,222	13,490	31,286	17,710	30,046	16,454

Table 4–8 Disturbance by Sub-watershed and Soil Type

		Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
Sub-watershed	Soil Type[1]	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
	WY051	684	327	786	429	755	398
	WY082	7,515	3,820	8,637	5,015	8,294	4,659
	WY124	3,350	1,660	3,850	2,179	3,697	2,024
	WY125	9,546	4,714	10,972	6,189	10,537	5,750
	WY126	889	429	1,022	564	981	524
	WY128	13,269	6,584	15,250	8,644	14,646	8,031
	WY130	1,464	742	1,683	975	1,616	905
	WY209	19	21	22	28	21	26
	WY315	5	5	5	7	5	6
	Total	71,880	35,678	82,612	46,839	79,338	43,517
Upper Tongue River	*WY049*	6,663	3,449	7,095	3,861	6,745	3,504
	WY051	374	194	398	217	378	197
	WY055	2,412	1,279	2,569	1,432	2,442	1,299
	WY056	10	12	11	13	10	12
	WY057	10	12	11	13	10	12
	WY060	5	6	5	7	5	6
	WY063	5	6	5	7	5	6
	WY064	2,189	1,141	2,331	1,277	2,216	1,159
	WY065	2,036	1,049	2,168	1,174	2,061	1,065
	WY066	2,382	2,597	3,067	3,359	2,412	2,638
	Total	16,087	9,744	17,658	11,359	16,284	9,898
Total in Project Area		211,992	108,799	230,886	127,693	222,860	119,667

Note:
1. Italics designated soil types with severe hazards.

Slope Hazards

While the Project Area contains a large range of slopes (Figure 3–6), all wells, roads and production facilities have been located on gentle to moderate slopes to minimize construction costs and erosion hazards. This would reduce potential for water and wind erosion by reducing steep slopes and surface disturbance associated with large cuts and fills.

The slope ranges and figures used for this analysis are very general and some wells may be located on more severe slopes than currently shown on Figure 3–6. Specific facility locations and roadways should be assessed for slope and any related erosion hazards and soil instabilities. Steep slopes should be avoided where possible, especially on soils susceptible to erosion. On gentle to moderate slopes, soil loss due to wind and water erosion could be effectively controlled by following the COAs.

Water Erosion Hazards

Water erosion is a concern with soil series WY049, WY050, WY051, WY065, WY066, WY206, WY208, WY209, WY210 and WY211 located in eastern Sheridan County, northern and western Campbell County, throughout Converse County and in Johnson County along the I-25 corridor to Buffalo, and along the Powder River (Figure 4–42). These series all have one or more major constituents that have low permeability and high K-factors, making them susceptible to water erosion (Appendix F). Approximately 76,691 acres in the short term and 38,452 acres in the long term would be disturbed on soils with a high water erosion potential.

Table 4–9 Disturbance by Sub-watershed and Hazard

		Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
Sub-watershed	Hazard	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Antelope	Wind Erosion	3,292	1,452	3,374	1,508	3,339	1,483
	Water Erosion	5,291	2,253	5,422	2,340	5,367	2,301
	Compaction	30,402	12,606	31,163	13,102	30,847	12,885
	Salinity	None	None	None	None	None	None
	Poor Revegetation	5611	2449	5750	2544	5691	2502
	Prime Agricultural	22,549	9,436	23,114	9,806	22,879	9,644
Clear Creek	Wind Erosion	None	None	None	None	None	None
	Water Erosion	13,842	7,526	14,996	8,681	14,174	7,825
	Compaction	7,486	4,121	8,110	4,754	7,665	4,286
	Salinity	None	None	None	None	None	None
Clear Creek	Poor Revegetation	13,911	7,562	15,071	8,723	14,244	7,863
	Prime Agricultural	15,714	8,516	17,025	9,823	16,091	8,854
Crazy Woman Creek	Wind Erosion	None	None	None	None	None	None
	Water Erosion	3,167	1,455	3,631	1,921	3,462	1,753
	Compaction	9,984	4,744	11,442	6,264	10,912	5,716
	Salinity	None	None	None	None	None	None
	Poor Revegetation	12,039	5,689	13,798	7,512	13,158	6,855
	Prime Agricultural	7,804	3,675	8,945	4,854	8,530	4,429
Dry Fork Cheyenne	Wind Erosion	92	83	93	84	92	83
	Water Erosion	141	127	143	130	142	129
	Compaction	49	44	50	46	50	46
	Salinity	None	None	None	None	None	None
	Poor Revegetation	162	146	164	149	163	148
	Prime Agricultural	124	112	126	115	125	114
Lightning Creek	Wind Erosion	137	123	139	126	138	125
	Water Erosion	166	149	169	153	167	152
	Compaction	29	26	30	27	29	27
	Salinity	None	None	None	None	None	None
	Poor Revegetation	166	149	169	153	167	152
	Prime Agricultural	141	127	144	130	142	129
Little Bighorn	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards
Little Missouri	Wind Erosion	None	None	None	None	None	None
	Water Erosion	21	19	21	19	21	19
	Compaction	None	None	None	None	None	None
	Salinity	None	None	None	None	None	None
	Poor Revegetation	21	19	21	19	21	19
	Prime Agricultural	None	None	None	None	None	None
Little Powder	Wind Erosion	7,393	3,339	7,797	3,641	7,601	3,493
Little Powder	Water Erosion	4,200	2,681	4,430	2,923	4,318	2,804
	Compaction	1,623	885	1,711	965	1,668	926
	Salinity	None	None	None	None	None	None
	Poor Revegetation	7,511	3,894	7,921	4,246	7,722	4,073
	Prime Agricultural	6,808	3,075	7,179	3,353	6,999	3,217
Middle Fork Powder	Wind Erosion	None	None	None	None	None	None
	Water Erosion	None	None	None	None	None	None
	Compaction	None	None	None	None	None	None
	Salinity	None	None	None	None	None	None
	Poor Revegetation	None	None	None	None	None	None
	Prime Agricultural	8	7	8	8	8	8
Middle North Platte Casper	Wind Erosion	58	53	59	53	59	53
	Water Erosion	70	64	72	64	72	64
	Compaction	33	30	34	30	34	30
	Salinity	None	None	None	None	None	None
	Poor Revegetation	91	83	93	83	93	83
	Prime Agricultural	91	83	93	83	93	83
Middle Powder	Wind Erosion	1,312	733	1,434	863	1,377	802
	Water Erosion	6,219	3,253	6,799	3,832	6,528	3,560
	Compaction	2,303	1,259	2,518	1,483	2,417	1,378
	Salinity	None	None	None	None	None	None
	Poor Revegetation	3,595	1,787	3,931	2,106	3,774	1,956
	Prime Agricultural	2,315	1,267	2,532	1,493	2,430	1,387

Table 4–9 Disturbance by Sub-watershed and Hazard

Sub-watershed	Hazard	Disturbance					
		Alternative 1		Alternative 2A		Alternative 2B	
		Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
North Fork Powder	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards
Salt Creek	Wind Erosion	13	12	13	13	13	13
	Water Erosion	543	235	564	253	561	252
	Compaction	348	137	361	147	359	146
	Salinity	None	None	None	None	None	None
	Poor Revegetation	882	364	916	391	911	389
Salt Creek	Prime Agricultural	9	8	9	9	9	9
South Fork Powder	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards	No Hazards
Upper Belle Fourche	Wind Erosion	8,208	4,654	8,355	4,748	8,223	4,630
	Water Erosion	None	None	None	None	None	None
	Compaction	17,406	8,946	17,718	9,128	17,437	8,900
	Salinity	562	322	572	328	563	320
	Poor Revegetation	1,420	1,194	1,445	1,218	1,422	1,188
	Prime Agricultural	22,204	11,889	22,601	12,130	22,244	11,828
Upper Cheyenne	Wind Erosion	None	None	None	None	None	None
	Water Erosion	34	33	36	36	35	34
	Compaction	2,790	1,440	2,917	1,554	2,850	1,491
	Salinity	14	15	15	16	15	16
	Poor Revegetation	53	53	56	58	54	55
	Prime Agricultural	162	97	169	105	166	101
Upper Powder River	Wind Erosion	19	21	22	28	21	26
	Water Erosion	32,526	16,074	37,382	21,102	35,900	19,605
	Compaction	30,883	15,369	35,494	20,177	34,086	18,744
	Salinity	None	None	None	None	None	None
	Poor Revegetation	48,903	24,281	56,205	31,877	53,976	29,616
	Prime Agricultural	14,324	7,064	16,463	9,275	15,809	8,616
Upper Tongue River	Wind Erosion	None	None	None	None	None	None
	Water Erosion	11,455	7,289	12,728	8,611	11,596	7,404
	Compaction	9,226	4,784	9,824	5,355	9,339	4,860
	Salinity	None	None	None	None	None	None
	Poor Revegetation	11,081	7,095	12,330	8,394	11,218	7,207
	Prime Agricultural	16,056	9,709	17,628	11,320	16,254	9,862

Construction and operation activities could potentially increase soil loss due to water erosion. Removal of vegetation for any activity exposes soils to increased water erosion. Excavation associated with construction of pads, roads and reservoirs could steepen slopes and cause the breakdown of soil aggregates, increasing runoff and gully formation. Pipeline trenches could change erosion patterns if soils settle in the backfilled trench after reclamation and form gullies. Compaction of the soils in pads, roads and reservoirs could decrease infiltration, promoting high runoff. Any water handling method which would release produced water to the surrounding area could increase water erosion. However, increased water availability would also increase vegetation, partially mitigating any erosive effects.

Figure 4–42 Soils and Existing and Proposed CBM Wells

The Revised Universal Soil Loss Equation (RUSLE) was used to compute soil loss due to raindrop splash and runoff (USDA 1997). Estimates were calculated using three conditions: (1) undisturbed (existing rangeland condition); (2) construction (during construction and prior to reclamation); and (3) reclaimed (one year after reclamation, assuming 40 percent vegetative cover). The assumption of 40 percent vegetative cover one year after reclamation was based on information used for soil loss calculations on CBM projects in the region (BLM 1999a). In order to simplify calculations, all factors, except for K, were assumed to be consistent throughout the Project Area, even though soil loss would be variable throughout the Project Area. The highest and lowest K factors for the 23 disturbed soils were used to estimate the maximum and minimum soil loss in the Project Area. For the undisturbed condition, soil loss estimates ranged from 0.1 to 0.6 tons/acre/year. During construction, soil loss estimates ranged from 3.4 to 18.7 tons/acre/year. One year following reclamation, soil loss estimates ranged from 0.5 to 2.6 tons/acre/year. These calculations were based on slopes 400 feet long having a slope gradient of three percent on undisturbed ground.

RUSLE calculations were done to estimate soil loss increases on disturbed land due to overland flow. Water erosion in drainages downstream from CBM activities due to runoff the release of produced water could increase but this erosion cannot be accurately predicted using RUSLE. A more detailed description of erosive effects to drainages is contained in the Surface Drainages section of the Surface Water section.

Soil loss would likely increase substantially in the short-term following disturbance until reclamation measures became effective in controlling runoff. In addition, soil loss during construction would exceed acceptable levels for all of the disturbed soil series in the Project Area (NRCS Soil Surveys). These potential effects point to a need for adoption of COAs during the life of the project.

Soil loss can be reduced substantially by avoiding highly erosive areas like badlands, steep-walled drainages, blowout areas and other areas subject to active headward erosion (BLM 1999c). Locating roads and pads in areas where cuts and fills would not be required, surfacing of roads and pads, installing drainage controls, and reseeding and installing water bars across reclaimed areas would also aid in reducing soil loss. Pipeline trenches should be mounded when backfilled to prevent soil settling and forming gullies. COAs such as these have resulted in very little accelerated erosion and a high level of reclamation success on the Marquiss Project, located south of Gillette (BLM 1999a).

Sedimentation

Sedimentation in streams and rivers in the Project Area is an important result of soil loss, but can not be adequately estimated simply by calculating soil loss. The movement of eroded soil materials to drainages can be blocked or facilitated by relief, climate, vegetation, and bedrock geology. Due to these characteristics, there is a large difference between soil loss and sediment flow. Sedimentation would be variable throughout the Project Area, but in general only ten percent of soil loss would remain in the water flow at the point of exit from the subwatersheds (Blatt et al. 1972). The remaining 90 percent would never reach flowing water or be deposited in the streambeds of the watershed. Sedimentation deposition could alter water quality and the fluvial characteristics of drainages in the Project Area and point to a need for COAs associated with water erosion to control sedimentation. Water in the drainages should be monitored for high levels of TDS as well. The Surface Drainages section also contains information on the effects of sedimentation on drainages.

Compaction/Shrink-Swell Potential

Compaction is a concern with soil series WY004, WY049, WY051, WY064, WY082, WY124, WY128, WY129, WY130, WY208, and WY210 located throughout Campbell and Converse counties and eastern Sheridan and Johnson counties (Figure 4–42). These series all have one or more major constituents that include very compactable clay loams (Appendix F). Approximately 113,998 acres in the short term and 55,829 acres in the long term would be disturbed on compactible soil. Clay grains are extremely small and can be forced so closely together that few pore spaces remain. Thus, most air and water is pushed out of the soil and plants roots would be unable to penetrate the soil. Due to the absence of air and water and the difficulty of root growth, reclamation of a tightly compacted clay soil can be difficult. Compacted soils also have low permeability, and runoff is high, adding to water erosion.

Activity on well pads, production facilities and roads, and storage of water in reservoirs have the potential to compact soils. COAs would minimize both short and long-term effects. Pad and road construction, and traffic on highly compactable soils should be minimized wherever possible, and soils should be loosened prior to reseeding during reclamation. COAs to reduce water erosion should be employed on compactible soils due to the high runoff potential.

Salinity

Only one soil series, WY004 is listed by the NRCS's Soil Surveys as having high salinity (Appendix F). Approximately 558 acres in the short term and 312 acres in the long term would be disturbed on this soil. This statement is misleading, as the salinity of soils like most chemical characteristics is highly variable and can change drastically over a few feet. Any soil in the Project Area can be saline, depending on the quality of nearby surface water, plant species, and drainage characteristics. Decisions on the locations of water disposal facilities that could affect soil salinity and other chemical levels should be based on these parameters.

Due to the variable nature of produced water and differing characteristics of soils in the Project Area, water handling options could have significant effects on soils. Five water handling options are included under Alternative 1: injection; surface discharge (including infiltration and irrigation); infiltration reservoirs; containment reservoirs; and LAD. Injection would affect soils in the Project Area the least, having effects similar to CBM well construction and production activities. After injection, containment would introduce the least amount of produced water to the surrounding soils. These reservoirs should be lined or compacted to prevent produced water from inundating the soils below. Due to the large size of the reservoirs, compaction is the most reasonable method to reduce infiltration. Locating containment reservoirs on compactable soils where infiltration would be ten percent or less would also help to reduce effects on soils. Of course, soils below these reservoirs would be affected by this compaction and infiltration.

COAs should be followed during construction of reservoirs to prevent erosion. Even with COAs, reclamation would be very difficult based on sheer size of the area, amount of soil moved, the concentrated compaction below the reservoir, and the material remaining after the produced water has evaporated.

Surface discharge (including infiltration and irrigation), infiltration reservoirs and LAD would introduce the most produced water to the surrounding soils. Due to the deleterious effect of high SAR water on soil productivity and reclamation potential, care should be taken that produced water is not discharged near or applied to highly saline soils. The sodium capacity of each soil should be known, application should be halted when that capacity is reached, and the soil should be reclaimed. Halting the application of produced water to reclaim the soil would be much more difficult in the reservoirs then under LAD or surface discharge. General Guidance for Land Application of CBM Produced Water should be followed to mitigate effects to soils (Appendix F).

Suitability for irrigation is dependent upon interaction of soil types, SAR values, salinity values, and crops grown. The decision to use produced water for irrigation should be made on a site-by-site basis.

Undesired consequences could also occur should produced water from CBM wells be discharged at points within closed basins. Water discharged within a closed basin would drain to the low point of the basin or playa. The sustained release of produced water from CBM wells could accumulate in closed basins as water is evaporated leaving its dissolved minerals, like sodium, behind as solids. Also, regardless of the salinity levels in the inflows and playa soils, the long-term ponding of playa bottoms would alter the normally dry soil/playa bottom conditions and would result in changes in soil conditions (BLM 1999c).

The development of saline and wet soil conditions could be minimized by avoiding discharge in or upstream from areas where water could become concentrated in the soils or where soils are already saline. Even with these practices, water quality and soils in the Project Area should be monitored for high salinity and SAR levels.

Effects similar to those described in closed basins could occur in infiltration reservoirs. Avoiding constructing infiltration reservoirs on highly saline areas would reduce the effects to soils. Locating reservoirs on area where water could easily move through the soils, such as soils with low potential for compaction, high permeability and porous bedrock would reduce the potential for saturation of the soil.

Reclamation of saline soils can be difficult and no method that works in all situations has yet been found. Possible methods include raising salt-resistant crops, and repeatedly flooding the affected area with low SAR water. The success of these methods would depend on soils types, salinity values, and drainage characteristics of the area.

Poor Revegetation Potential

Poor revegetation potential is a concern with soil series WY049, WY050, WY065, WY066, WY082, WY125, WY127, WY206, WY207, WY208, WY209, WY210, and WY211 located in northern Campbell County, throughout Converse County, east of Interstate-25 in Sheridan County, and in Johnson County along the Interstate-25 corridor to Buffalo, and along the Powder River (Figure 4–42). These series all have capability classes indicating that the soil would respond poorly to reclamation (Appendix F). About 108,292 acres in the long term and 55,139 acres in the short term would be disturbed on soils with poor revegetation potential.

All previously discussed hazards have a potential effect on revegetation potential. Thus, COAs associated with all other categories in this section would aid in reclamation. Mixing of soil materials during excavation or compaction, especially in soil series listed above, where one or two dominant soils have poor revegetation potential, could have an effect on reclamation and future productivity. The COAs do not mention avoiding soil mixing, but this mitigation measure is recommended by numerous soil surveys in the area. WY206 and WY211 should be avoided in areas where the soil is shallow or on steep slopes as all three major soil types in these series have poor revegetation potential.

Prime Agricultural Soils

Prime agricultural soils are found in soil series WY004, WY048, WY049, WY051, WY055, WY064, WY065, WY066, WY124, WY126, WY130, WY207, WY208, WY209, and WY210 located in central Campbell County, throughout Converse and Sheridan Counties, in Johnson County along the Interstate-25 corridor, and along the Powder River (Figure 4–42). These series all have one or more major constituents identified by the Wyoming state office of the Natural Resources Conservation Service as Prime Agricultural Soils (Appendix F). About 106,068 acres in the short term and 52,414 acres in the long term would be disturbed on Prime Agricultural soils.

All previously discussed hazards have a potential effect on soil productivity. Thus, COAs associated with all other categories in this section would aid in reclamation. Mixing of soils that are not prime agricultural soils with prime agricultural soils during excavation or compaction could have an effect on reclamation and future productivity.

Alternative 2

Alternative 2A

Under this alternative, 230,886 total acres of disturbance would occur in the short term and 127,693 acres in the long term. This is an increase in area of about 18,894 acres from Alternative 1, which can be entirely attributed to a change in water handling methods. Table 4–8 and Table 4–9 show disturbances for each soil and hazard type under this alternative.

Alternative 2A emphasizes the use of infiltration impoundments to dispose of CBM produced water. Surface discharge (and all associated treatments) would be decreased and LAD and containment reservoirs would be increased. The increase in disturbed acreage would correspond to not only a rise in soil loss, but a change in the type of disturbance as well.

Per acre, reservoirs require much more construction than surface discharge due to the amount of excavation. Reservoirs also cause much deeper soil disturbance, increasing the chance for mixing of soils layers. Based on the amount of excavation and the depth of disturbance, construction of reservoirs would lead to greater stockpiles of soils, increasing the chance for wind and water erosion. A greater number of reservoirs would also increase compaction of the soils due to construction and the weight of the water. Because water discharge to natural drainages would have a much higher infiltration rate than the infiltration and containment reservoirs, actual infiltration of produced water would be decreased under Alternative 2A. Effects to soils downstream from Project Area would probably be reduced under a reduction in surface discharge. Increased LAD would increase the amount of infiltration, but this increase would be offset by decrease in surface discharge. In all, Alternative 2A would reduce surface discharge and infiltration, but would increase the potential for wind and water erosion, soil mixing, and compaction.

Alternative 2B

Under this alternative, 222,860 total acres of disturbance would occur in the short term and 119,667 acres in the long term. This is a decrease in area by 8,026 acres from Alternative 2A, and an increase in area of 10,868 acres from Alternative 1, which can be entirely attributed to a change in water handling methods. Table 4–8 and Table 4–9 show disturbances for each soil and hazard type under this alternative.

The decrease in total disturbed acreage from Alternative 2A is due to the increase in surface discharge (and all associated treatments) and the decrease in infiltration and containment impoundments. Like Alternative 2A, Alternative 2B employs greater infiltration impoundments and LAD with less surface discharge than Alternative 1.

Differences in disturbance from Alternative 1 be would similar to those described in Alternative 2A, except on a smaller scale. Due to the increase in surface discharge and decrease in containment and infiltration reservoirs, infiltration would increase, but the potential for wind and water erosion, soil mixing, and compaction would decrease from Alternative 2A to Alternative 2B.

Alternative 3

The No Action Alternative would not authorize additional natural gas development of federal leases within the Project Area. No wells on federal minerals would be drilled, but facilities associated with fee and state wells could be built on federal surface. Wells on private and state leases would probably be drilled. Under this alternative, 90,807 total acres of disturbance would occur in the short term and 45,057 in the long term. This would correspond to a decrease in disturbance and soil loss. Water handling methods would be proportionate to Alternative 1.

Cumulative Effects

Alternative 1

By the end of 2001, approximately 12,077 CBM wells would have been drilled in the Project Area (Figure 4–42). Assuming one third of these wells would still be under construction, these wells and their associated facilities would disturb an estimated 12,372 acres in the short term and 14,936 acres in the long term. As much as 17,600 acres may be affected by future non-CBM well development in the long run and 14,432 acres in the short term.

Due to the widespread nature of CBM development, concentrated impacts on soils are not likely, except at reservoirs, LAD sites, and pipeline routes. Other resources in the Project Area could be affected by the changes in soils as well. The large amounts of disturbed and stockpiled soils at reservoirs and LAD sites could affect air quality in the area due to wind erosion. Additional wildlife and cattle usage around reservoirs would further disturb soils through increased traffic and loss of vegetation cover. If trenches were allowed to gully, long pipelines could change drainage patterns in the sub-watersheds. Sedimentation from water erosion could change water quality and fluvial characteristics of streams and rivers in the sub-watersheds of the Project Area. Since disturbed soils with a conductivity of 16 mmhos/cm could release as much as 0.8 tons/acre/year of sodium, SAR of water in the sub-watersheds could be altered by saline soils (BLM 1999). Soils in floodplains and streambeds may also be affected by high SAR and TDS produced water. Methane migration could affect soils by driving oxygen out and producing toxic levels of sulfur, both of which could reduce the productivity in the soil.

In addition to oil and gas activities, uranium, coal, sand, gravel and scoria mining occur within the Project Area. In 20 years, the long-term surface disturbances associated with reasonably foreseeable mineral and energy resource projects may be 165,000 acres or about two percent of the Project Area. Construction activities, such as excavation, compaction, and soil mixing, related to mining would affect soils in much the same way as activities related to CBM activities.

Due to the potential effects on prime agricultural soils and water quality in the project area, impacts to agriculture could occur. CBM facilities should be located with agricultural concerns in mind, and TDS and SAR should be monitored, especially in water used for irrigation, livestock, and human consumption.

Disturbance related to urban and residential acres and recreational activities may increase due to increased CBM activity. Recreational activities, like hunting and off-roading, could increase due to the proliferation of roads from CBM development. While urban and residential development would likely follow COAs for mitigation of effects to soils, recreationists may not. Traffic on CBM roads should be monitored to insure that unnecessary impacts to soils do not occur.

Alternative 2A

The cumulative impacts of Alternative 2A are not expected to vary from those described for Alternative 1.

Alternative 2B

The cumulative impacts of Alternative 2B are not expected to vary from those described for Alternative 1.

Alternative 3

Due to the decreased amount of CBM activity under Alternative 3, all cumulative impacts described for Alternative 1 are expected to decrease, except those related to mineral and energy resource projects.

Air Quality and Climate

No significant, adverse impacts to climate are anticipated from implementation of any development alternative. Potential impacts to air quality were analyzed as described below.

Issues, Impact Types, and Criteria

Fugitive dust and exhaust from construction activities, along with air pollutants emitted during operation (i.e., well operations, injection well and pipeline compressor engines, etc.), are potential causes of unacceptable decreases in air quality. These issues are more likely to generate public concern where natural gas development activities occur near residential areas. The Crow Tribal Council and the Federal Land Managers (FLMs) have expressed concerns regarding potential visibility and atmospheric deposition (acid rain) impacts within distant downwind PSD Class I and PSD Class II areas in Wyoming, Montana, southeastern North Dakota, eastern South Dakota, and northwestern Nebraska.

Potential air quality impacts from potential development were analyzed and reported in the sections on Alternative 1 (Proposed Action) and Cumulative Impacts. This analysis was prepared solely under the requirements of NEPA to assess and disclose reasonably foreseeable impacts to both the public and the Bureau decision maker before a Record of Decision is issued. Due to the preliminary nature of this NEPA analysis, it should be considered a “reasonable, but conservative” upper estimate of predicted impacts. Actual impacts at the time of development (subject to air pollutant emission source permitting) are likely to be less.

The air quality impact assessment was based on the best available engineering data and assumptions, meteorology data, and dispersion modeling procedures, as well as professional and scientific judgment. However, where specific data or procedures were not available, “reasonable, but conservative” assumptions were incorporated. For example, the Alternative 1 air quality impact assessment assumed that all CBM wells would go into production (no dry holes), then operate at full production levels (no shut-ins) for about seven years, with an overall 20-year life of project (LOP).

Potential direct, indirect and cumulative air quality impacts were analyzed to predict maximum potential near-field ambient air pollutant concentrations and potential hazardous air pollutant (HAP) impacts, as well as to determine maximum far-field ambient air pollutant concentrations, visibility and atmospheric deposition (acid rain) impacts.

Air pollution impacts are limited by state, tribal and Federal regulations, standards, and implementation plans established under the Clean Air Act and administered by the applicable air quality regulatory agency (including the Wyoming Department of Environmental Quality - Air Quality Division (WDEQ-AQD) or the EPA). Although not applicable to the development alternatives, the Departments of Environmental Quality for Montana, South Dakota, and Nebraska have similar jurisdiction over potential air pollutant emission sources in their respective States, which can have a cumulative impact with WDEQ-AQD approved sources. Air quality regulations require proposed new, or modified existing, air pollutant emission sources (including gas compression facilities) undergo a permitting review before their construction can begin. Therefore, the applicable air quality regulatory agencies have the primary authority and responsibility to review permit applications and to require emission permits, fees and control devices, prior to construction and/or operation. The U.S. Congress (through the Clean Air Act Section 116) also authorized local, state and tribal air quality regulatory agencies to establish air pollution control requirements more (but not less) stringent than Federal requirements. Additional site-specific air quality analysis would be performed, and additional emission control measures (including a BACT analysis and determination) may be required by the applicable air quality regulatory agencies to ensure protection of air quality resources.

In addition, under FLPMA and the Clean Air Act, BLM cannot authorize any activity that does not conform to all applicable local, state, tribal and Federal air quality laws, statues, regulations, standards, and implementation plans. An extensive air quality impact assessment technical support document was prepared to analyze potential impacts from the development alternatives, as well as other reasonably foreseeable emission sources, and is available for review (Argonne 2001).

The significance criteria for potential air quality impacts include state, tribal and federally enforced legal requirements to ensure air pollutant concentrations will remain within specific allowable levels. These requirements include the National and Wyoming Ambient Air Quality Standards which set maximum limits for several air pollutants, and PSD increments which limit the incremental increase of certain air pollutants (including NO_2, PM_{10}, SO_2) above legally defined baseline concentration levels. These legal limits are presented in Table 3-13.

Where legal limits have not been established, the BLM uses the best available scientific information to identify thresholds of significant adverse impacts. Thresholds have been identified for HAP exposure, incremental cancer risks, a “just noticeable change” in potential visibility impacts, and potential atmospheric deposition impacts to sensitive lake water chemistry. Specific threshold levels are described under Alternative 1 (Proposed Action) and under Cumulative Impacts.

Impacts Common to All Alternatives

Air quality impacts would occur during construction (due to potential surface disturbance by earth-moving equipment, vehicle traffic fugitive dust, well testing, and drilling rig and vehicle engine exhaust) and production (including non-CBM well production equipment, booster and reciprocating pipeline compression engine exhausts). The amount of air pollutant emissions during construction would be controlled by watering disturbed soils, and by air pollutant emission limitations imposed by applicable air quality regulatory agencies. Actual air quality impacts depend on the amount, duration, location and emission characteristics of potential emissions sources, as well as meteorological conditions (wind speed and direction, precipitation, relative humidity, etc.).

Alternative 1

Significant air quality impacts would not occur under this Alternative. No violations of applicable state, tribal or Federal air quality regulations or standards are expected to occur as a result of direct, indirect, or cumulative CBM and non-CBM development-related air pollutant emissions (including construction and operation).

Air pollutant dispersion modeling was performed to quantify potential “reasonable, but conservative” PM_{10} and SO_2 impacts during construction based on the individual pollutant’s period of maximum potential emissions. The EPA CALPUFF dispersion model was used with meteorological data generated by the MM4 (mesoscale model) and CALMET models. These meteorology data were combined with air pollutant emission values to predict maximum potential concentrations in the vicinity of assumed well and compressor engine emission sources for comparison with applicable air quality standards and PSD Class II increments (Argonne 2001).

Construction emissions would occur during potential road and well pad construction, well drilling, and well completion testing. During well completion testing, natural gas may be vented. Since the burned natural gas is “sweet” (does not contain sulfur compounds), no objectionable odors are likely to occur.

Maximum potential near-field particulate matter emissions from traffic on unpaved roads and during well pad construction were used to predict the maximum 24-hour and annual average PM_{10} concentrations. Maximum air pollutant emissions from each well would be temporary (i.e., occurring during a short construction period) and would occur in isolation, without significantly interacting with adjacent well locations. Particulate matter emissions from well pad and resource road construction would be minimized by application of water. The control efficiency of the dust suppression was computed at 50 percent during construction.

The maximum potential particulate matter concentrations at least 650 feet (200 m) from road and 0.5 miles (805 m) from well emission sources (including representative background values) would be nearly 55 µg/m^3 (24-hour PM_{10}), well below the 24-hour PM_{10} NAAQS of 150 µg/m^3. In addition, predicted particulate matter concentrations would decrease rapidly beyond 200 m from the emission source. Since these PM_{10} construction emissions would be temporary, PSD increments are not applicable.

The predicted maximum 24-hour concentrations over-estimate actual expected PM_{10} concentrations because the maximum modeled concentrations from the proposed activities are assumed to coincide with the maximum measured background concentrations. However, the meteorological conditions that lead to both situations would be very different, and are not likely to occur at the same location and the same time.

The maximum short-term (3- and 24-hour) SO_2 emissions would be generated by drilling rigs and other diesel engines used during rig-up, drilling, and completion operations (sulfur is a trace element in diesel fuel). These SO_2 emissions would be temporary, occurring only during the temporary construction period at each well location. The maximum modeled concentrations (including representative background values of 8 µg/m^3) would be nearly 18 µg/m^3 (3-hour) and 12.5 µg/m^3 (24-hour).

Therefore, predicted short-term SO_2 concentrations would be below the 3-hour SO_2 National and Wyoming Ambient Air Quality Standards of 1,300 µg/m^3 (3-hour), as well as the Wyoming SO_2 Ambient Air Quality Standard of 260 µg/m^3 (24-hour). Since these SO_2 construction emissions would be temporary, PSD increments are not applicable.

Air pollutant dispersion modeling was also performed to quantify potential “reasonable, but conservative” CO, NO_2 and HAP impacts during operation, based on the period of maximum potential emissions and other emission sources located in the Project Area (including Alternative 1 and other reasonably foreseeable sources.) Operation emissions (primarily CO and NO_x) would occur due to increased compression requirements, including booster and reciprocating pipeline compressor stations. It is anticipated additional field-wide compression would be approximately 800,000 hp (at more than 250 new compressor station locations). Since produced natural gas is nearly pure methane and ethane, with little or no liquid hydrocarbons, no significant direct VOC emissions would occur due to well operations.

The maximum direct CO impacts during operation were predicted to be nearly 855 µg/m^3 (1-hour) and 796 µg/m^3 (8-hour). When these values are added to the assumed background concentrations of 3,500 µg/m^3 and 1,500 µg/m^3, respectively, they become 4354 µg/m^3 (1-hour) and 2295 µg/m^3 (8-hour), demonstrating compliance with both the Wyoming and NAAQS of 40,000 µg/m^3 (1-hour) and 10,000 µg/m^3 (8-hour).

Maximum direct NO_2 impacts during operations were predicted based on assumed oxides of nitrogen (NO_x) emissions from reasonably foreseeable CBM recovery wells, and booster and reciprocating pipeline compressor engines. A NO_x emissions rate of 1.5 g/hp-hr was used. Compressor engines recently permitted by the WDEQ-AQD have an average potential NO_x emission rate of 1.0 g/hp-hr. The maximum potential near-field NO_2 concentrations were determined by multiplying maximum predicted NO_x concentrations by 0.75, in accordance with standard EPA methodology (40 CFR 51, Appendix W, Section 6.2.3).

The maximum predicted direct annual NO_2 impact was 14.2 $\mu g/m^3$, which is nearly 57 percent of the applicable annual PSD Class II increment of 25 $\mu g/m^3$. When this value is added to the assumed representative background concentration (16.5 $\mu g/m^3$), the resulting predicted maximum total impact of 30.7 $\mu g/m^3$ is also well below the applicable NO_2 NAAQS of 100 $\mu g/m^3$ (annual).

As stated previously, all NEPA analysis comparisons to the PSD Class II increments are intended to evaluate a threshold of concern, and do not represent a regulatory PSD Increment Consumption Analysis.

Maximum HAP (formaldehyde) impacts were predicted for the booster and reciprocating pipeline compressor engines. Since neither the WDEQ-AQD nor EPA have established HAP standards, predicted 8-hour HAP concentrations were compared to a range of 8-hour state maximum Acceptable Ambient Concentration Levels (AACL; EPA 1997a). The maximum predicted cumulative 8-hour formaldehyde impact was 11.5 $\mu g/m^3$, which is within the range of states' AACLs of 4.5 $\mu g/m^3$ (Pinnellas County Air Pollution Control Board, Florida) to 71 $\mu g/m^3$ (State of Nevada, Division of Environmental Protection, Air Quality Control). The maximum formaldehyde concentration was predicted to occur at 320 m (less then 1/4 mile) adjacent to a compressor station; as the distance from the emission source increases, the predicted concentrations decrease rapidly.

Long-term (70-year) exposures from suspected carcinogenic emissions (e.g., formaldehyde) were used to estimate the minimum distance for residential incremental cancer risk exposure below acceptable thresholds. These were calculated based on EPA (1997b) unit risk factors for carcinogenic constituents. Two estimates of cancer risk were made; one that corresponds to a most likely exposure (MLE) condition, and one reflective of the maximally exposed individual (MEI). The estimated cancer risks were adjusted to account for duration of exposure and time spent at home.

Under the MLE scenario, the estimated distance from the largest compressor engine to experience an incremental cancer risk below the 1×10^{-6} to 100×10^{-6} threshold (associated with long-term exposure to formaldehyde) would be 350 meters. Under the MEI analysis, the estimated distance would be 400 meters. Therefore, the predicted incremental cancer risks for the inhalation pathway all fall below the 1×10^{-6} to 100×10^{-6} threshold range beyond 400 meters from the largest compressor engine. This distance would be even further for smaller compressors. Given the conservative nature of these analyses, the predicted exposures are likely to overstate actual exposures, and the potential incremental cancer risks would not be significant.

When reviewing the predicted near-field development alternative impacts, it is important to understand the "reasonable, but conservative" assumptions made regarding potential resource development. In developing this analysis, there is uncertainty regarding ultimate development (i.e., number of wells, equipment to be used, specific locations). The analysis was also based on a reasonably foreseeable development scenario, including several conservative assumptions:

- Maximum assumed background air pollutant concentrations were assumed to occur throughout the LOP at all locations in the region, even though monitoring is primarily conducted in urban or industrial areas, rather than the relatively clean rural areas. In addition, the maximum predicted air quality impacts would occur only in the vicinity of the anticipated emission sources. Actual impacts would be less further away from the predicted points of maximum.
- All emission sources were assumed to operate at their reasonably foreseeable maximum emission rates simultaneously throughout the LOP. Given the number of sources included in this analysis, the co-probability of such a scenario actually occurring over an entire year (or even 24-hours) is small. While this assumption is typically used in modeling analyses, the resulting predicted impacts will be overstated.
- All proposed natural gas wells were assumed to be fully operational (no dry holes), and remain operating (no shut ins) for about 7 years, with an overall 20-year LOP.
- The total proposed booster and reciprocating pipeline compression engines (nearly 800,000 hp) were assumed to operate at their rated capacities continuously throughout the LOP (no phased increases or reductions). In reality, compression equipment would be added or removed incrementally as required by the well field operation, compressor engines would operate below full horsepower ratings, and it is unlikely all compressor stations would operate at maximum levels simultaneously.
- Total predicted short-term air pollutant impact concentrations were assumed to be the sum of the assumed maximum background concentration, plus the predicted maximum cumulative modeled concentrations, which actually occur under very different meteorological conditions and are not likely to coincide.
- The HAP analyses assumed all equipment would operate simultaneously at the maximum emission levels continuously throughout the overall 20 year LOP.

Given these numerous “reasonable, but conservative” analysis assumptions, which may actually compound one another, the predicted impacts represent an upper estimate of potential air quality impacts which are unlikely to actually be reached. However, even applying these “reasonable, but conservative” analysis assumptions, predicted impacts are below applicable regulatory limits, and the scientific evidence is not compelling that reasonably foreseeable significant adverse impacts would occur.

It is important to note that before actual development could occur, the applicable air quality regulatory agencies (including the state, tribe or EPA) would review specific air pollutant emissions pre-construction permit applications that examine source-specific air quality impacts. As part of these permits (depending on source size), the air quality regulatory agencies could require additional air quality impacts analyses or mitigation measures. Thus, before development occurs, additional site-specific air quality analyses would be performed to ensure protection of air quality.

Alternatives 2A and 2B

Significant air quality impacts would not occur under this Alternative. Potential air quality impacts would be less than those described under Alternative 1 (Proposed Action) above.

Alternative 3

Significant air quality impacts would not occur under this Alternative. Potential air quality impacts would be less than those described under Alternative 1 (Proposed Action) above.

Impacts from Temporary Generation

The exact number of temporary natural gas and diesel generators for compressor stations cannot be predicted, but at any one time there may be as many as 400 portable diesel generators and 70 portable gas generators operating. Typical emission factors for these generators are shown on Table 4–10. Table 4–11 shows the potential ground-level concentrations resulting from operation of these temporary generators.

Table 4–10 Emission factors for Temporary Generation

Pollutant	Emission Factor Range (g/hp-hr)
NO_x	0.7 – 1.5
PM_{10}	0.03 – .07
SO_2	0.002
CO	0.3 – 2.0
VOC	0.5 – 1.0
HCHO	0.05 – 0.2

Table 4–11 Near-Field Concentrations from a Single Temporary Generator

Pollutant	Averaging Time	Concentration Range ($\mu g/m^3$)	WAAQS ($\mu g/m^3$)
NO_2	Annual	1.9 – 7.5	100
SO_2	Annual	0.007 – 0.013	60
	24 hour	0.09 – 0.3	260
	3 hour	0.2 – 0.4	1300
$PM_{10}/PM_{2.5}$	Annual	0.1 – 0.4	15
	24 hour	1.5 – 5.3	65
CO	8 hour	33.2 – 242.9	10,000
	1 hour	55.3 – 403.1	40,000

Cumulative Impacts

Based on a separate assessment predicting potential far-field (cumulative) air quality impacts (Argonne 2001), the EPA CALMET/CALPUFF dispersion model was used to predict maximum potential air quality impacts at downwind mandatory Federal PSD Class I areas, and other "sensitive receptors," to: 1) determine if the PSD Class I NO_2 increment might be exceeded; 2) calculate potential nitrate and sulfate atmospheric deposition (and their related impacts) in sensitive lakes; and 3) predict potential impacts to visibility (regional haze).

Meteorological information was assembled to characterize atmospheric transport and dispersion from several data sources, including:

- 20 km gridded MM4 (mesoscale model) values with continuous four-dimensional data assimilation.
- Hourly surface observations (wind speed, wind direction, temperature, cloud cover, ceiling height, surface pressure, relative humidity, and precipitation).
- Twice-daily upper air vertical profiles (wind speed, wind direction, temperature and pressure).
- PRISM adjusted hourly precipitation measurements.

Potential "reasonable, but conservative" air pollutant emissions from Alternative 1 (Proposed Action) sources were combined with other reasonably foreseeable facilities to determine the total potential cumulative air quality impacts. These other "reasonably foreseeable" facilities included development associated with: 1) approximately 458 emission sources permitted by the WDEQ-AQD; 2) approximately 34 emission sources permitted by the MTDEQ-AWM; and 3) approximately 13 emission sources permitted within the states of North Dakota, South Dakota and Nebraska.

As described under Alternative 1 above, potential NO_x emissions from reasonably foreseeable booster and reciprocating compressor stations, and SO_2 emissions from construction equipment, were analyzed to predict potential impacts at 16 PSD Class I areas located in Wyoming, Montana, North and South Dakota (Argonne 2001). Table 4–12 presents the maximum modeled concentration at the specified PSD Class I Area; other PSD Class I areas had lower predicted impacts. Therefore, all potential direct cumulative NO_2 and SO_2 impacts would be at or below applicable PSD Class I increments.

Table 4–12 Maximum Predicted PSD Class I Area Cumulative Impacts (in $\mu g/m^3$) - Alternative 1

Pollutant/Averaging Period	Class I Area	Maximum Modeled Concentration	Class I Increment
Nitrogen dioxide - Annual	Wind Cave NP	0.5	2.5
Sulfur dioxide - Annual	Wind Cave	0.13	2
Sulfur dioxide - 24-hour	N. Cheyenne Res.	1.38	5
Sulfur dioxide - 3-hour	N. Cheyenne Res.	3.69	25

It should be noted that this comparison is not a complete PSD Increment Consumption Analysis, but an assessment indicating that the increment would not be exceeded by the cumulative emission sources. Many of the potential air pollutant emission sources were analyzed at their maximum permitted levels; actual emissions and their related air quality impacts are typically less. At the time of a preconstruction air quality permit application, the applicable air quality regulatory agencies may require a much more detailed PSD Increment Consumption Analysis.

Several lakes within four FS designated wilderness areas were identified as being sensitive to atmospheric deposition and for which the most recent and complete data have been collected. The FS has also identified the following "Limit of Acceptable Change" regarding potential changes in lake chemistry: no more than a 10 percent change in acid neutralizing capacity (ANC) for those water bodies where the existing ANC is at or above 25 microequivalents per liter (μeq/l) and no more than a 1 μeq/l change for those extremely sensitive water bodies where the existing ANC is below 25 μeq/l. Based on a Rocky Mountain Region FS screening method (FS 2000), Table 4–13 demonstrates that potential impacts to sensitive lakes would be below applicable significance thresholds from the Alternative 1 emission sources. No sensitive lakes were identified by either the NPS or USFWS.

Table 4–13 Predicted Total Cumulative Change in Acid Neutralizing Capacity at Sensitive Area Lakes (percent change)

Sensitive Area	Lake	Baseline ANC (μeq/L)	Area (hectares)	Change (percent)	Thresholds (percent)
Bridger Wilderness Area	Black Joe Lake	69.0	890	0.8	10
	Deep Lake	61.0	205	0.9	10
	Hobbs Lake	68.0	293	0.3	10
Cloud Peak Wilderness Area	Emerald Lake	55.3	293	4.1	10
	Florence Lake	32.7	417	7.8	10
Fitzpatrick Wilderness Area	Ross Lake	61.4	4,455	0.4	10

Since the development alternative and cumulative air pollutant emission sources constitute many small sources spread out over a very large area, discrete visible plumes are not likely to affect the mandatory Federal PSD Class I areas, but the potential for cumulative visibility impacts (increased regional haze) is a concern. Regional haze degradation is caused by fine particles and gases scattering and absorbing light. Potential changes to regional haze are calculated in terms of a perceptible "just noticeable change" (1.0 deciview) in visibility when compared to background conditions.

A 1.0 deciview change is considered a small but noticeable change in haziness as described in the Preamble to the EPA Regional Haze Regulations (64 FR 35725, III.C.). A 1.0 deciview change is defined as about a 10 percent change in the extinction coefficient (corresponding to a 2 to 5 percent change in contrast, for a "black target" against a clear sky, at the most optically sensitive distance from an observer), which is a small but noticeable change in haziness under most circumstances when viewing scenes in mandatory Federal Class I areas.

It should be noted that a 1.0 deciview change is not a "just noticeable change" in all cases for all scenes. Visibility changes less than 1.0 deciview are likely to be perceptible in some cases, especially where the scene being viewed is highly sensitive to small amounts of pollution, such as due to preferential forward light scattering. Under other view-specific conditions, such as where the sight path to a scenic feature is less than the maximum visual range, a change greater than 1.0 deciview might be required to be a "just noticeable change."

However, this NEPA analysis is not designed to predict specific visibility impacts for specific views in specific mandatory Federal PSD Class I areas based on specific project designs, but to characterize reasonably foreseeable visibility conditions that are representative of a fairly broad geographic region, based on "reasonable, but conservative" emission source assumptions. This approach is consistent with both the nature of regional haze and the requirements of NEPA. At the time of a pre-construction air quality PSD permit application, the applicable air quality regulatory agency may require a much more detailed visibility impact analysis. Factors such as the magnitude of deciview change, frequency, time of the year, and the meteorological conditions during times when predicted visibility impacts are above the 1.0 deciview threshold (as well as inherent conservatism in the modeling analyses) should all be considered when assessing the significance of predicted impacts.

The FS, NPS and USFWS have published their "Final FLAG Phase I Report" (Federal Register, Vol. 66 No. 2, dated January 3, 2001), providing "a consistent and predictable process for assessing the impacts of new and existing sources on AQRVs" including visibility. For example, the FLAG report states "A cumulative effects analysis of new growth (defined as all PSD increment-consuming sources) on visibility impairment should be performed," and further, "If the visibility impairment from the proposed action, in combination with cumulative new source growth, is less than a change in extinction of 10 percent [1.0 deciview] for all time periods, the FLMs will not likely object to the proposed action." In addition, the FLAG procedures were also applied using WDEQ-AQD provided background extinction values.

Although the FLAG procedures were primarily designed to provide analysis guidance to Clean Air Act PSD permit applicants, Table 4–14 uses the "Final FLAG Phase I Report" procedures for this NEPA analysis.

Table 4–14 Predicted Visibility Impacts in PSD Class I Areas from Cumulative Sources — FLAG Method (Number of Days Predicted to Equal or Exceed a 1.0 Deciview "Just Noticeable Change")

Class I Area	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Badlands National Park	3	3	3	2
Bridger Wilderness Area	0	0	0	0
Fitzpatrick Wilderness Area	0	0	0	0
N. Absaroka Wilderness Area	1	0	0	0
N. Cheyenne Reservation	10	10	9	6
Washakie Wilderness Area	1	1	1	0
Wind Cave National Park	4	3	3	2

Based on multiple iterations of the non-steady state CALPUFF dispersion modeling system, including the CALMET meteorological model, for five different development alternatives, potential visibility impairment of 1.0 dV or greater ranged from none to ten days. In addition, the air quality impact assessment also analyzed potential visibility (regional haze) impacts at nine PSD Class II areas not subject to the Clean Air Act visibility protection regulations.

If visibility impacts are predicted to equal or exceed 1.0 deciview at any PSD Class I area based on the FLAG/WYO analysis, then a daily impact analysis based on monitored optical and relative humidity conditions should be performed.

Since the 1.0 deciview threshold was predicted to be reached at Northern Cheyenne Reservation based on the FLAG analysis methodology, the maximum modeled impacts to that area were compared to representative measured optical and relative humidity values on a daily basis.

When reviewing the predicted cumulative impacts, it is important to understand the “reasonable, but conservative” assumptions made regarding potential resource development. In developing this analysis, there is uncertainty regarding ultimate development (i.e., number of wells, equipment to be used, specific locations). The analysis was also based on a reasonably foreseeable development scenario, including several conservative assumptions:

- All emission sources were assumed to operate at their reasonably foreseeable maximum emission rates simultaneously throughout the LOP. Given the number of sources included in this analysis, the co-probability of such a scenario actually occurring over an entire year (or even 24-hours) is small. While this assumption is typically used in modeling analyses, the resulting predicted impacts will be overstated.
- All proposed natural gas wells were assumed to be fully operational (no dry holes), and remain operating (no shut ins) for about 7 years, with an overall 20-year LOP.
- The total proposed booster and reciprocating pipeline compression engines (nearly 800,000 hp) were assumed to operate at their rated capacities continuously throughout the LOP (no phased increases or reductions). In reality, compression equipment would be added or removed incrementally as required by the well field operation, compressor engines would operate below full horsepower ratings, and it is unlikely all compressor stations would operate at maximum levels simultaneously.
- The atmospheric deposition impact analysis assumed no other ecosystem components would affect lake chemistry for a full year (assuming no chemical buffering due to interaction with vegetation or soil materials).
- The visibility impact analysis assumed seasonal “natural background” optical conditions would occur simultaneously every day throughout each mandatory Federal PSD Class I Area, and that a 1.0 deciview “just noticeable change” would be a reasonably foreseeable significant adverse impact, although there is no applicable state, tribal or Federal regulatory visibility standards.

Table 4–15 Predicted Visibility Impacts in PSD Class I Areas — Daily Analysis Method (Number of Days Predicted to Equal or Exceed a 1.0 Deciview "Just Noticeable Change")

PSD Class I Area	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Northern Cheyenne Reservation											
Alternative 1	6	6	10	13	8	11	9	14	12	11	14
Alternative 2A	6	6	9	13	8	8	8	14	10	11	13
Alternative 3	4	3	7	9	4	4	6	9	5	6	7

Given these numerous "reasonable, but conservative" analysis assumptions, which may actually compound one another, the projected impacts represent an upper estimate of potential air quality impacts which are unlikely to actually be reached. However, even applying these "reasonable, but conservative" analysis assumptions, most predicted impacts are below assumed threshold limits, and scientific evidence is not compelling that reasonably foreseeable significant adverse impacts would occur.

It is important to note that before actual development could occur, the applicable air quality regulatory agencies (including the state, tribe or EPA) would review specific air pollutant emissions preconstruction permit applications which examine source-specific air quality impacts. As part of these permits (depending on source size), the air quality regulatory agencies could require additional air quality impacts analyses or mitigation measures. Thus, before development occurs, additional site-specific air quality analyses would be performed to ensure protection of air quality.

Vegetation

Direct effects to vegetation would occur from ground disturbance due to construction of well pads, compressor stations, ancillary facilities, associated pipelines, and roads. Short-term effects would occur where vegetated areas are disturbed but later reclaimed within one to three years of the initial disturbance. Long-term effects would occur where well pads, compressor stations, roads, water-handling facilities, or other semi-permanent facilities result in loss of vegetation and prevent reclamation for the life of the Project. These areas would be reclaimed during the abandonment phase. There would be some permanent loss of vegetation for roads and other facilities that are not reclaimed.

Indirect effects to vegetation would occur as a result of Project activities other than the direct disturbance or removal of vegetation. Possible indirect effects may include: 1) an increase in the potential for the spread of noxious weeds and displacement of native vegetation, due to increased ground disturbance in the Project Area; 2) alteration of vegetation type distribution due to changes in volume and rate of surface water flows, particularly changes in stream flow from intermittent to perennial; 3) alteration of ecosystem biodiversity due to changes in plant species composition, abundance, and distribution; and 4) changes in vegetation type distribution which are important to wildlife species dependent on these types as habitat.

Alternative 1

Direct Effects

Under Alternative 1, direct disturbance would be the primary impact to vegetation resources in the Project Area. Approximately 278,633 acres (3.5 percent of the Project Area) would be directly disturbed in the short-term. Of the 14 vegetation types within the Project Area, direct disturbance would occur across all land ownership types in 13 vegetation types including agriculture, barren, coniferous forest, forested riparian, herbaceous riparian, mixed-grass prairie, other shrublands, sagebrush shrublands, shortgrass prairie, shrubby riparian, urban/disturbed, water, and wet meadow Table 4–16. The aspen vegetation type would not be disturbed. Direct disturbance of vegetation would occur in each of the 18 subwatersheds within the Project Area (Table 4–17).

Table 4–16 Short-term Vegetation Disturbance by Surface Owner — Alternative 1

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	31	0	0	146	2,075	2,252
Aspen	0	0	0	0	0	0
Barren	362	0	4	286	2,578	3,229
Coniferous Forest	203	0	9	148	822	1,182
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	6	0	0	0	6
Mixed Grass Prairie	2,518	11	303	4,060	29,181	36,073
Other Shrublands	11	0	0	17	28	56
Sagebrush Shrublands	8,800	22	3,606	5,375	68,174	85,978
Shortgrass Prairie	18,715	33	7,665	9,091	107,045	142,550
Shrubby Riparian	15	0	6	116	1,171	1,307
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	10	403	413
Wet Meadow	20	0	22	707	4,820	5,569
Total	30,676	72	11,615	19,957	216,313	278,633

Table 4–17 Short-term Vegetation Disturbance by Sub-watershed — Alternative 1

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	851	0	213	19	0	0	7,523	0	3,086	3,456	416	0	0	2,707	18,270
Middle Fork Powder River	0	0	0	10	6	0	22	33	22	39	0	0	0	0	132
North Fork Powder River	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
Upper Powder River	69	0	1,106	259	0	0	8,530	0	29,900	55,008	128	0	0	463	95,462
South Fork Powder River	0	0	0	6	0	0	6	0	0	6	0	0	0	0	18
Salt Creek	0	0	0	59	0	0	0	0	204	1,004	0	0	0	0	1,268
Crazy Woman Creek	0	0	395	12	0	0	1,197	6	6,489	10,533	0	0	0	0	18,631
Clear Creek	1,124	0	205	39	0	0	6,130	6	4,491	6,495	509	0	403	1,774	21,176
Middle Powder River	27	0	43	206	0	0	1,478	0	2,031	2,833	6	0	0	88	6,712
Little Powder River	58	0	317	488	0	0	6,159	0	12,429	9,458	136	0	0	253	29,298
Little Missouri River	6	0	0	6	0	0	259	0	143	94	0	0	0	11	519
Antelope Creek	53	0	192	32	0	0	443	0	10,257	34,433	0	0	0	0	45,410
Dry Fork Cheyenne River	6	0	11	0	6	0	105	0	50	94	0	0	0	0	272
Upper Cheyenne River	0	0	28	10	0	0	266	0	2,003	1,496	0	0	0	0	3,803
Lightning Creek	6	0	6	0	0	0	116	11	105	28	0	0	0	0	272
Upper Belle Fourche River	52	0	697	37	0	0	3,695	0	14,696	17,573	113	0	10	273	37,146
Middle North Platte Casper	0	0	17	0	0	6	116	0	66	0	0	6	0	0	211
Total	2,252	0	3,229	1,182	11	6	36,073	56	85,978	142,550	1,307	6	413	5,569	278,633

The area of long-term disturbances associated with the Project would be less than the extent of disturbances presented in (Table 4–16 and Table 4–17). Long-term disturbance would affect 128,064 acres (1.6 percent of the Project Area). The initial area disturbed during the construction phase is typically larger than the area required for the operation phase. After completion of each well and associated roads and other facilities, portions of the disturbed areas would be reclaimed. Long-term disturbance would still occur in the same 13 vegetation types as would short-term disturbance, but the total area that remained disturbed would be less. Total long-term disturbance by land ownership type is shown in Table 4–18. The areal extent of vegetation that would be permanently lost is not known at this time because the percentage of roads to be left unreclaimed is not yet known.

Table 4–18 Long-term Vegetation Disturbance by Surface Owner — Alternative 1

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	17	0	0	73	998	1,088
Aspen	0	0	0	0	0	0
Barren	183	0	2	132	1,238	1,554
Coniferous Forest	122	0	37	86	493	738
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	5	0	0	0	5
Mixed Grass Prairie	1,216	9	248	1,927	14,126	17,525
Other Shrublands	9	0	0	14	23	46
Sagebrush Shrublands	3,975	18	1,792	2,525	31,696	40,007
Shortgrass Prairie	8,218	27	3,413	4,,064	47,849	63,571
Shrubby Riparian	10	0	5	60	237	312
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	5	202	207
Wet Meadow	10	0	18	345	2,627	3,001
Total	13,760	59	5,515	9,231	99,504	128,069

Long-term disturbance would also occur in all 18 sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–19.

Several options for handling CBM produced waters, including surface discharge, infiltration, containment, land application disposal (LAD), and injection, would also be implemented and would result in short- and long-term disturbance to vegetation in the Project Area. Details of the water handling options are discussed in Chapter 2. Water handling options would directly disturb vegetation in ten of the 18 sub-watersheds within the Project Area (Tables 2-6 and 2-7). The total amount of vegetation disturbed as a result of water handling methods (32,685 acres) for Alternative 1 would be more than that for Alternative 3 because of the greater number of wells, but less than both Alternatives 2A and 2B, where the same number of wells would be drilled, but different water handling methods would be used.

Table 4–19 Long-Term Vegetation Disturbance by Sub-watershed — Alternative 1

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	18	0	5	0	0	0	0	0	23
Upper Tongue River	415	0	102	10	0	0	3,559	0	1,431	1,647	156	0	0	1,326	8,645
Middle Fork Powder River	0	0	0	9	5	0	18	27	18	32	0	0	0	0	109
North Fork Powder River	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Upper Powder River	36	0	513	129	0	0	3,836	0	13,478	24,744	14	0	0	242	42,991
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	23	0	0	0	0	100	399	0	0	0	0	523
Crazy Woman Creek	0	0	154	8	0	0	511	5	2,777	4,511	0	0	0	0	7,965
Clear Creek	539	0	105	24	0	0	3,011	5	2,236	3,188	107	0	202	992	10,409
Middle Powder River	14	0	24	106	0	0	740	0	928	1,347	5	0	0	59	3223
Little Powder River	24	0	172	366	0	0	3,162	0	6,459	4,946	22	0	0	198	15,349
Little Missouri River	5	0	0	5	0	0	212	0	117	77	0	0	0	9	425
Antelope Creek	20	0	74	15	0	0	173	0	3,897	13,053	0	0	0	0	17,232
Dry Fork Cheyenne River	5	0	9	0	5	0	86	0	41	77	0	0	0	0	223
Upper Cheyenne River	0	0	16	7	0	0	98	0	967	737	0	0	0	0	1,825
Lightning Creek	5	0	5	0	0	0	95	9	86	23	0	0	0	0	223
Upper Belle Fourche River	25	0	367	32	0	0	1,901	0	7,413	8,785	9	0	5	175	18,712
Middle North Platte Casper	0	0	14	0	0	5	95	0	54	0	0	5	0	0	173
Total	1,088	0	1,554	738	9	5	17,525	46	40,007	63,571	312	5	207	3,001	128,069

Where surface discharge is selected as the water handling option, produced water from CBM wells would be gathered for surface discharge, feeding a small stock reservoir or constructed infiltration basin designed for flow through (including possible passive or active treatment) and subsequent discharge to a nearby surface drainage. Surface discharge associated with Alternative 1 would cause direct disturbance to vegetation on 7,296 acres typically from the construction of flow through ponds. Where infiltration is selected as the water handling option, shallow impoundments would be constructed in upland or bottomland areas where soils would allow infiltration of produced water. Water would not be released from these impoundments into surface drainages. Atomizers would be used to enhance water evaporation. The construction of infiltration impoundments would result in direct impacts to 14,566 acres of vegetation. Where containment is selected as the water handling option, shallow impoundments would be constructed in upland areas where soils would allow only minimal infiltration. Water would not be released from these impoundments into surface drainages. Atomizers would be used to enhance water evaporation. Direct effects to vegetation due to the creation of containment reservoirs would encompass 5,169 acres. Where LAD is selected as the water handling option, disposal likely would be accomplished using atomizers or irrigation equipment under a disposal-rest rotation cycle consisting of disposal, soil amendment, rest, disposal, etc., until the limitations of repeated soil amendments are reached, and the site reclaimed. It is assumed that all water would either evaporate or be consumed by vegetation and that infiltration and surface runoff would be negligible. Direct effects to vegetation at LAD sites would result in the direct disturbance of 1,780 acres. Where injection is selected as the water handling option, direct effects to vegetation caused by construction at injection well sites would result in direct disturbance to vegetation on 3,873 acres.

Indirect Effects

Implementation of Alternative 1 would cause indirect effects to vegetation types within the Project Area. Following the life of the Project, most facilities would be removed and their disturbed areas would be reclaimed and returned to pre-project uses. This restoration would typically include replacing salvaged topsoil, regrading where necessary, reseeding disturbed areas, and controlling noxious weeds. Reclamation of all native vegetation types present in the Project Area, particularly sagebrush shrublands, would be difficult to achieve. Efforts directed toward successful reclamation of all Project disturbances would be continued until reclamation is successful. Replacement of pre-disturbance vegetation communities would potentially be a long-term effort due to the difficulty in replicating native plant communities. Forested areas, shrublands, and even native grasslands would remain in a low-diversity state for an extended period of time (i.e., years to decades) until natural plant species recruitment re-establishes the pre-disturbance level of diversity.

Disturbances from construction would increase the potential for the invasion and establishment of noxious weed species. Noxious weeds tend to be aggressive invaders of disturbed areas. Disturbances associated with the construction of well pads, compressor stations, roads, reservoirs, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. The extent of these invasions is difficult to predict and would be determined by many factors, including the extent of disturbed areas, the extent of existing weed infestations that would provide a seed source, the amount of equipment movement from areas infested with weeds to areas not yet infested, the effectiveness of mitigation measures designed to prevent noxious weed infestations, and the time lag between the end of disturbance and the successful completion of reclamation.

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. The increased availability of water along normally dry stream channels would cause an increase in the extent of riparian and wetland vegetation, and a corresponding decrease in upland vegetation that formerly occupied these areas. This shift in vegetation types would provide another type of disturbance that could be exploited by noxious weed species. The extent of these changes is dependent on the locations chosen for discharge points and on the existing vegetation downstream of these points.

Other than the alteration of vegetation along drainages, other changes in vegetation patterns may occur. Large, contiguous stands of vegetation would be fragmented by the construction of well pads, roads, pipeline corridors, and other facilities. Disturbance followed by reclamation would alter the species composition of reclaimed areas when compared with undisturbed areas by replacing diverse native communities with communities consisting of a few favored reclamation species.

The increased availability of water at LAD sites would increase ground cover and productivity and alter species composition, thus providing a potential opportunity for aggressive species to establish, including noxious weeds. Water application at LAD sites would likely reduce the presence of certain plant species that are not tolerant of irrigation, such as sagebrush, while favoring species that are capable of exploiting the increased amount of water that would be available. The introduction of salts in produced water at LAD sites could alter soil chemistry and affect both plant species composition and biomass production. Excessive salt build-up in soils could result in decreases in productivity and loss of native species that are sensitive to high salt concentrations. Soil chemistry would be monitored during the life of the project and mitigation measures applied to reduce these impacts. Use of a rest-rotation system of water application, or the use of soil amendments to reduce salt concentrations are two possible mitigations. These measures would be developed on a site-specific basis, taking into account local soil properties, vegetation species present, the particular salts or other contaminants that are causing problems, and the objectives of the managing agency or surface owner.

The long-term effect of these shifts in vegetation patterns would be a reduction in biodiversity within and adjacent to disturbed areas. Where the native vegetation provides an essential component of wildlife habitat, such as the requirement of sage grouse for large, healthy stands of sagebrush, these shifts in vegetation patterns would result in decreased habitat quality for wildlife. Some of these changes in vegetation would occur in areas that have been specifically identified as being important to the conservation of biological diversity. The alteration and potential loss of biodiversity associated with project-related activities is difficult to quantify, but is not expected to have any substantial effect on biodiversity in the Project Area as a whole or within each sub-watershed. Even if all plant species diversity in the entire disturbed area were to be reduced to some rudimentary level, only a small percentage of the landscape in each sub-watershed would be affected. The remaining undisturbed vegetation would still retain a level of biodiversity essentially equivalent to pre-project conditions.

Alternatives 2A and 2B

Direct Effects

Under Alternative 2, direct disturbance would be similar to Alternative 1. Within Alternative 2, two different ratios of the various water handling options (Alternatives 2A and 2B) have been analyzed. All disturbance associated with these alternatives would occur in the same vegetation types, land ownerships, and sub-watersheds as Alternative 1. Table 4–20 and Table 4–24 show the direct, short-term disturbance by surface owner for Alternatives 2A and 2B, respectively. Table 4–21 and Table 4–25 show the direct, long-term disturbance by surface owner for Alternatives 2A and 2B, respectively. Table 4–22 and Table 4–26 show the direct, short-term disturbance by sub-watershed for Alternatives 2A and 2B, respectively. Table 4–23 and Table 4–27 show the direct, long-term disturbance by sub-watershed for Alternatives 2A and 2B, respectively. Total vegetation disturbance under Alternative 2A would encompass 297,527 acres (3.8 percent of the Project Area) in the short-term and 146,963 acres (1.9 percent of the Project Area) in the long-term. Total vegetation disturbance under Alternative 2B would encompass 289,501 acres (3.7 percent of the Project Area) in the short-term and 138,937 acres (1.8 percent of the Project Area) in the long-term.

Table 4–20 Short-term Vegetation Disturbance by Surface Owner — Alternative 2A

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	33	0	0	155	2,192	2,379
Aspen	0	0	0	0	0	0
Barren	390	0	4	311	2,774	3,479
Coniferous Forest	215	0	10	157	868	1,250
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	6	0	0	0	6
Mixed Grass Prairie	2,692	11	303	4,331	31,065	38,402
Other Shrublands	11	0	0	17	28	56
Sagebrush Shrublands	9,402	22	3,817	5,773	72,900	91,914
Shortgrass Prairie	19,901	33	8,208	9,731	114,462	152,335
Shrubby Riparian	15	0	6	123	1,200	1,344
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	11	430	441
Wet Meadow	21	0	22	751	5,110	5,905
Total	32,680	72	12,369	21,360	231,046	297,527

The primary difference between Alternative 1 and 2, in terms of direct disturbance of vegetation, would be in the relative proportion of disturbance caused by the different types of water disposal methods. Water handling options would directly disturb vegetation in ten of the 18 sub-watersheds within the Project Area (Tables 2-23 and 2-24 for Alternative 2A; Tables 2-25 and 2-26 for Alternative

2B). The total amount of vegetation disturbed as a result of water handling methods for Alternative 2A (51,579 acres) and Alternative 2B (43,553 acres) is more than for Alternative 1 because the construction of impoundments for either infiltration or containment purposes causes greater surface disturbance than direct discharge to surface drainages. Total disturbance for both of these alternatives is greater than for Alternative 3 because that alternative contains many fewer new wells.

Table 4–21 Long-term Vegetation Disturbance by Surface Owner — Alternative 2A

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	18	0	0	82	1,114	1,215
Aspen	0	0	0	0	0	0
Barren	210	0	2	156	1,435	1,804
Coniferous Forest	134	0	38	95	539	806
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	5	0	0	0	5
Mixed Grass Prairie	1,391	9	248	2,197	16,009	19,854
Other Shrublands	9	0	0	14	23	46
Sagebrush Shrublands	4,581	18	2,001	2,923	36,420	45,943
Shortgrass Prairie	9,412	27	3,951	4,704	55,262	73,356
Shrubby Riparian	11	0	5	67	266	349
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	6	229	235
Wet Meadow	11	0	18	390	2,918	3,337
Total	15,778	59	6,262	10,634	114,230	146,963

Where surface discharge is selected as the water handling option, surface discharge associated with Alternative 2A would cause direct disturbance to vegetation on 9,956 acres. Surface discharge associated with Alternative 2B would cause direct disturbance to vegetation on 4,769 acres. Where infiltration is selected as the water handling option, direct effects to vegetation due to the construction of infiltration reservoirs would encompass 32,253 acres for Alternative 2A and 23,446 acres for Alternative 2B. Where containment is selected as the water handling option, direct effects to vegetation due to the creation of containment reservoirs would encompass 5,941 acres for Alternative 2A and 4,939 acres for Alternative 2B. Where LAD is selected as the water handling option, direct effects to vegetation would result in the direct disturbance of 6,296 acres for both Alternative 2A and Alternative 2B. Where injection is selected as the water handling option, direct effects to vegetation caused by construction at injection well sites would result in direct disturbance to vegetation on 4,103 acres for both Alternative 2A and Alternative 2B.

Table 4–22 Short-term Vegetation Disturbance by Sub-watershed — Alternative 2A

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	887	0	233	20	0	0	7,934	0	3,797	3,976	528	0	0	2,,705	20,079
Middle Fork Powder River	0	0	0	11	6	0	22	33	33	59	0	0	0	0	164
North Fork Powder River	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
Upper Powder River	84	0	1,159	283	0	0	8,941	0	31,112	57,208	140	0	0	563	99,489
South Fork Powder River	0	0	0	6	0	0	6	0	0	6	0	0	0	0	18
Salt Creek	0	0	0	64	0	0	0	0	304	1,014	0	0	0	0	1,383
Crazy Woman Creek	0	0	436	12	0	0	1,297	6	6,789	11,528	0	0	0	0	20,067
Clear Creek	1,180	0	225	41	0	0	6,431	6	5,191	6,706	461	0	428	1,922	22,591
Middle Powder River	32	0	51	221	0	0	1,588	0	2,031	3,163	11	0	0	88	7,185
Little Powder River	62	0	351	505	0	0	6,561	0	12,829	10,139	128	0	0	293	30,868
Little Missouri River	7	0	0	6	0	0	359	0	153	104	0	0	0	11	640
Antelope Creek	58	0	224	33	0	0	483	0	11,278	36,503	0	0	0	0	48,579
Dry Fork Cheyenne River	7	0	13	0	6	0	128	0	50	104	0	0	0	0	308
Upper Cheyenne River	0	0	33	10	0	0	366	0	2,103	1,624	0	0	0	0	4,136
Lightning Creek	7	0	6	0	0	0	126	11	105	28	0	0	0	0	283
Upper Belle Fourche River	55	0	730	39	0	0	4,016	0	16,067	20,173	77	0	13	323	41,493
Middle North Platte Casper	0	0	19	0	0	6	116	0	66	0	0	6	0	0	212
Total	2,379	0	3,479	1,250	11	6	38,402	56	91,914	152,335	1,344	6	441	5,905	297,527

Table 4–23 Long-term Vegetation Disturbance by Sub-watershed — Alternative 2A

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	28	0	5	0	0	0	0	0	33
Upper Tongue River	475	0	112	10	0	0	3,900	0	1,631	1,757	166	0	0	1,426	9,476
Middle Fork Powder River	0	0	0	9	5	0	28	27	18	32	0	0	0	0	119
North Fork Powder River	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Upper Powder River	39	0	614	139	0	0	4,187	0	14,479	27,075	16	0	0	282	46,830
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	24	0	0	0	0	110	519	0	0	0	0	654
Crazy Woman Creek	0	0	164	8	0	0	631	5	3,777	5,921	0	0	0	0	10,505
Clear Creek	570	0	115	24	0	0	3,352	5	2,836	3,418	117	0	229	1,089	11,755
Middle Powder River	16	0	34	116	0	0	940	0	1,128	1,567	6	0	0	59	3,866
Little Powder River	34	0	182	403	0	0	3,683	0	7,482	5,739	36	0	0	257	17,816
Little Missouri River	6	0	0	5	0	0	232	0	117	87	0	0	0	9	456
Antelope Creek	30	0	84	25	0	0	293	0	4,938	16,174	0	0	0	0	21,544
Dry Fork Cheyenne River	5	0	9	0	5	0	96	0	41	87	0	0	0	0	243
Upper Cheyenne River	0	0	26	7	0	0	108	0	1,017	1,047	0	0	0	0	2,205
Lightning Creek	5	0	5	0	0	0	105	9	86	43	0	0	0	0	253
Upper Belle Fourche River	35	0	446	32	0	0	2,156	0	8,224	9,885	9	0	6	215	21,008
Middle North Platte Casper	0	0	14	0	0	5	105	0	54	0	0	5	0	0	182
Total	1,215	0	1,,804	806	9	5	19,854	46	45,943	73,356	349	5	235	3,337	146,963

Table 4–24 Short-term Vegetation Disturbance by Surface Owner — Alternative 2B

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	31	0	0	147	2,094	2,272
Aspen	0	0	0	0	0	0
Barren	378	0	4	300	2,692	3,374
Coniferous Forest	210	0	10	154	849	1,223
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	6	0	0	0	6
Mixed Grass Prairie	2,598	11	303	4,185	30,048	37,145
Other Shrublands	11	0	0	17	28	56
Sagebrush Shrublands	9,156	22	3,731	5,610	70,968	89,488
Shortgrass Prairie	19,443	33	7,998	9,483	111,594	148,550
Shrubby Riparian	15	0	6	117	1,176	1,314
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	10	408	418
Wet Meadow	20	0	22	716	4,879	5,637
Total	31,863	72	12,073	20,741	224,752	289,501

Table 4–25 Long-term Vegetation Disturbance by Surface Owner — Alternative 2B

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	17	0	0	75	1,017	1,108
Aspen	0	0	0	0	0	0
Barren	199	0	2	146	1,353	1,699
Coniferous Forest	129	0	38	91	521	779
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	5	0	0	0	5
Mixed Grass Prairie	1,296	9	248	2,051	14,993	18,597
Other Shrublands	9	0	0	14	23	46
Sagebrush Shrublands	4,333	18	1,916	2,761	34,489	43,517
Shortgrass Prairie	8,951	27	3,743	4,456	52,395	69,571
Shrubby Riparian	10	0	5	61	242	319
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	6	207	212
Wet Meadow	10	0	18	354	2,686	3,069
Total	14,955	59	5,968	10,015	107,939	138,937

Table 4–26 Short-term Vegetation Disturbance by Sub-watershed — Alternative 2B

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	860	0	233	20	0	0	7,724	0	3,486	3,756	558	0	0	2,637	19,273
Middle Fork Powder River	0	0	0	11	6	0	22	33	22	39	0	0	0	0	133
North Fork Powder River	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6
Upper Powder River	69	0	1,143	273	0	0	8,697	0	30,808	56,308	130	0	0	503	97,930
South Fork Powder River	0	0	0	6	0	0	6	0	0	6	0	0	0	0	18
Salt Creek	0	0	0	64	0	0	0	0	204	1,003	0	0	0	0	1,272
Crazy Woman Creek	0	0	422	12	0	0	1,197	6	6,489	11,133	0	0	0	0	19,258
Clear Creek	1,135	0	215	41	0	0	6,331	6	5,091	6,795	311	0	408	1,782	22,115
Middle Powder River	27	0	43	211	0	0	1,578	0	2,231	3,033	36	0	0	88	7,247
Little Powder River	58	0	337	498	0	0	6,461	0	13,129	10,259	219	0	0	283	31,244
Little Missouri River	6	0	0	6	0	0	259	0	143	94	0	0	0	11	519
Antelope Creek	53	0	202	33	0	0	443	0	10,458	35,533	0	0	0	0	46,722
Dry Fork Cheyenne River	6	0	12	0	6	0	105	0	50	94	0	0	0	0	273
Upper Cheyenne River	0	0	28	10	0	0	266	0	2,103	1,696	0	0	0	0	4,103
Lightning Creek	6	0	6	0	0	0	116	11	105	28	0	0	0	0	272
Upper Belle Fourche River	52	0	717	39	0	0	3,796	0	15,097	18,773	61	0	10	333	38,878
Middle North Platte Casper	0	0	17	0	0	6	116	0	66	0	0	6	0	0	211
Total	2,272	0	3,374	1,223	11	6	37,145	56	89,488	148,550	1,314	6	418	5,637	289,501

Table 4–27 Long-term Vegetation Disturbance by Sub-watershed — Alternative 2B

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	18	0	5	0	0	0	0	0	23
Upper Tongue River	421	0	122	10	0	0	3,660	0	1,631	1,947	160	0	0	1,336	9,286
Middle Fork Powder River	0	0	0	9	5	0	18	27	18	32	0	0	0	0	109
North Fork Powder River	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5
Upper Powder River	40	0	554	139	0	0	3,937	0	14,586	26,745	14	0	0	252	46,266
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	24	0	0	0	0	100	499	0	0	0	0	624
Crazy Woman Creek	0	0	174	8	0	0	611	5	3,077	4,911	0	0	0	0	8,785
Clear Creek	545	0	115	24	0	0	3,112	5	2,436	3,488	110	0	207	1,013	11,055
Middle Powder River	14	0	24	106	0	0	860	0	928	1,757	5	0	0	59	3,753
Little Powder River	28	0	182	396	0	0	3,462	0	7,059	4,646	22	0	0	222	16,017
Little Missouri River	5	0	0	5	0	0	232	0	117	77	0	0	0	9	445
Antelope Creek	20	0	84	15	0	0	273	0	4,198	15,234	0	0	0	0	19,824
Dry Fork Cheyenne River	5	0	9	0	5	0	86	0	41	77	0	0	0	0	223
Upper Cheyenne River	0	0	16	7	0	0	98	0	1,167	745	0	0	0	0	2,033
Lightning Creek	5	0	5	0	0	0	95	9	86	23	0	0	0	0	223
Upper Belle Fourche River	25	0	401	32	0	0	2,021	0	8,014	9,385	9	0	5	178	20,070
Middle North Platte Casper	0	0	14	0	0	5	104	0	54	0	0	5	0	0	182
Total	1,108	0	1,699	779	9	5	18,597	46	43,517	69,571	319	5	212	3,069	138,937

Indirect Effects

Indirect effects to vegetation as a result of Alternative 2 (both 2A and 2B) would be similar to those for Alternative 1. Disturbances associated with the construction of well pads, compressor stations, roads, reservoirs, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. The increased availability of water at LAD sites would increase ground cover and alter the species composition by providing opportunity for aggressive species, including noxious weeds, to establish.

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. This shift in vegetation types would provide another type of disturbance that could be exploited by noxious weed species. Disturbance followed by reclamation would alter the species composition of reclaimed areas. The long-term effect of these shifts in vegetation patterns would be a reduction in biodiversity within and adjacent to disturbed areas. The differences between the two water-handling scenarios in terms of indirect impacts are expected to be in proportion to the differences in direct impacts.

Alternative 3

Direct Effects

Under Alternative 3, direct disturbance would be the primary impact to vegetation resources in the Project Area. Approximately 112,299 acres (1.4 percent of the Project Area) would be directly disturbed in the short-term. Of the 14 vegetation types within the Project Area, direct short-term disturbance would occur across all land ownership types in 12 vegetation types including agriculture, barren, coniferous forest, forested riparian, mixed-grass prairie, other shrublands, sagebrush shrublands, shortgrass prairie, shrubby riparian, urban/disturbed, water, and wet meadow (Table 4–28). Direct disturbance of vegetation would occur in 17 of the 18 sub-watersheds within the Project (Table 4–29). The only sub-watershed not affected would be the North Fork Powder River sub-watershed.

Table 4–28 Short-term Vegetation Disturbance by Surface Owner — Alternative 3

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	0	0	0	146	1,958	2,105
Aspen	0	0	0	0	0	0
Barren	0	0	0	290	1,006	1,296
Coniferous Forest	0	0	0	146	211	358
Forest Riparian	0	0	0	0	11	11
Herbaceous Riparian	0	0	0	0	0	0
Mixed Grass Prairie	0	0	0	4,055	17,375	21,430
Other Shrublands	0	0	0	6	17	23
Sagebrush Shrublands	0	0	0	5,181	27,467	32,647
Shortgrass Prairie	0	0	0	8,474	39,282	47,756
Shrubby Riparian	0	0	0	116	471	587
Urban/Disturbed	0	0	0	0	6	6
Water	0	0	0	10	394	404
Wet Meadow	0	0	0	708	4,968	5,676
Total	0	0	0	19,133	93,166	112,299

The area of long-term disturbances associated with the Project would be less than the extent of disturbances presented in Table 4–28. Long-term disturbance would affect 52,231 acres (0.6 percent of the Project Area). The initial area disturbed during the construction phase is typically larger than the area required for the operation phase. After completion of each well and associated roads and other facilities, portions of the disturbed areas would be reclaimed. Long-term disturbance would still occur in the same twelve vegetation types as would short-term disturbance, but the total area that remained disturbed would be less. Total long-term disturbance by land ownership type is shown in Table 4–30. Long-term disturbance would also occur in the same seventeen sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–31.

The total amount of vegetation disturbed as a result of water handling methods for Alternative 3 would be less than any of the other alternatives because fewer wells would be drilled and less water would be produced, requiring fewer water handling facilities. Discharge of produced water associated with Alternative 3 would cause direct disturbance to vegetation on 14,384 acres (Tables 2-30 and 2-31).

Where surface discharge is selected as the water handling option, discharge of produced water associated with Alternative 3 would cause direct disturbance to vegetation on 8,376 acres. Where infiltration is selected as the water handling option, direct effects to vegetation due to the construction of infiltration reservoirs would encompass 7,141 acres for Alternative 3. Where containment is selected as the water handling option, direct effects to vegetation due to the creation of containment reservoirs would encompass 2,159 acres. Where LAD is selected as the water handling option, direct effects to vegetation would result in the direct disturbance of 808 acres. Where injection is selected as the water handling option, direct effects to vegetation caused by construction at injection well sites would result in direct disturbance to vegetation on 1,763 acres.

Indirect Effects

Implementation of Alternative 3 would result in lower potential for the occurrence of indirect effects to vegetation types within the Project Area than Alternatives 1 or 2, due to the reduced number of wells, roads, ancillary facilities, pipelines, and water handling facilities. Following the life of the project, most roads and facilities would be removed and their disturbed areas would be reclaimed and returned to pre-project uses.

Disturbances associated with the construction of well pads, compressor stations, roads, containment reservoirs, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. The increased availability of water at LAD sites would increase ground cover and alter the species composition by providing opportunity for invasive exotic species to establish.

Table 4–29 Short-term Vegetation Disturbance by Sub-watershed — Alternative 3

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	22	0	6	0	0	0	0	0	28
Upper Tongue River	825	0	174	20	0	0	6,595	0	2,523	2,341	317	0	0	2,652	15,446
Middle Fork Powder River	0	0	0	0	5.5	0	6	6	6	22	0	0	0	0	46
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	42	0	316	38	0	0	3,167	0	7,318	11,999	21	0	0	440	23,340
South Fork Powder River	0	0	0	6	0	0	6	0	17	6	0	0	0	0	35
Salt Creek	0	0	0	0	0	0	0	0	114	489	0	0	0	0	602
Crazy Woman Creek	0	0	75	6	0	0	680	0	2,005	3,409	0	0	0	0	6,174
Clear Creek	1,088	0	139	26	0	0	4,284	6	2,572	3,417	211	0	394	1,897	14,033
Middle Powder River	6	0	17	38	0	0	329	0	450	521	6	0	0	66	1,433
Little Powder River	58	0	105	181	0	0	3,402	0	5,147	3,701	26	0	0	260	12,878
Little Missouri River	6	0	0	0	0	0	94	0	22	39	0	0	0	11	172
Antelope Creek	53	0	107	27	0	0	272	0	3,229	11,268	0	0	0	0	14,956
Dry Fork Cheyenne River	6	0	0	0	5.5	0	39	0	11	33	0	0	0	0	95
Upper Cheyenne River	0	0	0	0	0	0	25	0	450	485	0	0	0	0	960
Lightning Creek	0	0	0	0	0	0	61	11	39	17	0	0	0	0	128
Upper Belle Fourche River	21	0	364	17	0	0	2,394	0	8,706	10,010	6	0	10	351	21,880
Middle North Platte Casper	0	0	0	0	0	0	55	0	33	0	0	6	0	0	94
Total	2,105	0	1,296	358	11	0	21,430	23	32,647	47,756	587	6	404	5,676	112,299

Table 4–30 Long-term Vegetation Disturbance by Surface Owner — Alternative 3

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	0	0	0	73	940	1,014
Aspen	0	0	0	0	0	0
Barren	0	0	0	134	492	626
Coniferous Forest	0	0	0	84	125	210
Forest Riparian	0	0	0	0	9	9
Herbaceous Riparian	0	0	0	0	0	0
Mixed Grass Prairie	0	0	0	1,934	8,361	10,295
Other Shrublands	0	0	0	5	14	19
Sagebrush Shrublands	0	0	0	2,461	12,851	15,311
Shortgrass Prairie	0	0	0	3,810	17,739	21,549
Shrubby Riparian	0	0	0	60	234	294
Urban/Disturbed	0	0	0	0	5	5
Water	0	0	0	5	198	203
Wet Meadow	0	0	0	346	2,350	2,696
Total	0	0	0	8,914	43,317	52,231

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. This shift in vegetation types would provide another type of disturbance that could be exploited by noxious weed species. Disturbance followed by reclamation would alter the species composition of reclaimed areas. The long-term effect of these shifts in vegetation patterns would be a reduction in biodiversity within and adjacent to disturbed areas. This effect would be less than Alternatives 1, 2A, and 2B for Alternative 3.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects to vegetation in the Project Area. Cumulative short- and long-term disturbance to vegetation by alternative for each surface owner is shown in Table 4–32. Cumulative short- and long-term disturbance to vegetation by alternative for each watershed is shown in Table 4–33. Included in Table 4–32 and Table 4–33 are the cumulative direct effects of oil and gas (both conventional and CBM) development, including projected effects of CBM development on private surface lands with private mineral ownership. The Alternative 3 data do not include potential new federal wells that would be developed in response to drainage situations caused by production on adjacent state or fee minerals. Additional oil and gas development (both conventional and CBM) may occur at a later date beyond the level of development being considered in this analysis. Other activities contributing to cumulative effects on vegetation in the Project Area include: coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing development.

Table 4–31 Long-term Vegetation Disturbance by Sub-watershed — Alternative 3

	Disturbance (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed Grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	18	0	5	0	0	0	0	0	23
Upper Tongue River	401	0	84	10	0	0	3,110	0	1,161	1,104	156	0	0	1,253	7,278
Middle Fork Powder River	0	0	0	0	5	0	5	5	5	18	0	0	0	0	38
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	23	0	146	18	0	0	1,379	0	3,319	5,399	9	0	0	185	10,477
South Fork Powder River	0	0	0	5	0	0	5	0	0	5	0	0	0	0	15
Salt Creek	0	0	0	0	0	0	0	0	52	189	0	0	0	0	240
Crazy Woman Creek	0	0	33	5	0	0	283	0	849	1,455	0	0	0	0	2,624
Clear Creek	521	0	70	15	0	0	2,116	5	1,274	1,670	106	0	198	905	6,879
Middle Powder River	5	0	10	20	0	0	172	0	223	236	5	0	0	44	715
Little Powder River	24	0	54	114	0	0	1,651	0	2,505	1,923	13	0	0	138	6,420
Little Missouri River	5	0	0	0	0	0	77	0	18	32	0	0	0	9	141
Antelope Creek	20	0	40	10	0	0	104	0	1,226	4,259	0	0	0	0	5,659
Dry Fork Cheyenne River	5	0	0	0	5	0	32	0	9	27	0	0	0	0	78
Upper Cheyenne River	0	0	0	0	0	0	12	0	232	257	0	0	0	0	501
Lightning Creek	0	0	0	0	0	0	50	9	32	14	0	0	0	0	105
Upper Belle Fourche River	10	0	190	14	0	0	1,237	0	4,375	4,962	5	0	5	163	10,962
Middle North Platte Casper	0	0	0	0	0	0	45	0	27	0	0	5	0	0	77
Total	1,014	0	626	210	9	0	10,295	19	15,311	21,549	294	5	203	2,696	52,231

Table 4–32 Cumulative Oil and Gas (including CBM) Direct Impacts to Vegetation by Alternative and Surface Owner

	Proportion of Surface Owner Area Disturbed							
	Alternative 1		Alternative 2A		Alternative 2B		Alternative 3	
Surface Owner	Short-Term (Percent)	Long-Term (Percent)	Short-Term (Percent)	Long-Term (Percent)	Short-Term (Percent)	Long-Term (Percent)	Short-Term (Percent)	Long-Term (Percent)
Buffalo FO	4.04	1.92	4.29	2.17	4.19	2.07	0.19	0.19
Casper FO	0.28	0.27	0.28	0.27	0.28	0.27	0.20	0.20
USFS	4.87	2.65	5.15	2.92	5.04	2.81	0.63	0.63
State	2.65	1.67	2.78	1.80	2.72	1.75	2.58	1.64
Private	4.96	2.89	5.22	3.15	5.11	3.04	2.78	1.90
Total	4.49	2.59	4.73	2.83	4.63	2.72	2.39	1.63

Table 4–33 Cumulative Oil and Gas (including CBM) Direct Impacts to Vegetation by Alternative and Sub-watershed

	Proportion of Sub-watershed Disturbed							
	Alternative 1		Alternative 2A		Alternative 2B		Alternative 3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn	0.06	0.05	0.06	0.07	0.06	0.05	0.06	0.05
Upper Tongue River	3.04	1.74	3.29	1.86	3.18	1.83	2.66	1.56
Middle Fork Powder	0.07	0.06	0.07	0.06	0.07	0.06	0.05	0.05
North Fork Powder	0.03	0.02	0.03	0.02	0.03	0.02	0.00	0.00
Upper Powder River	6.73	3.45	6.98	3.69	6.88	3.66	2.23	1.43
South Fork Powder	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17
Salt Creek	1.00	0.51	1.07	0.59	1.00	0.57	0.56	0.32
Crazy Woman Creek	3.53	1.59	3.80	2.05	3.65	1.74	1.26	0.62
Clear Creek	4.15	2.19	4.41	2.43	4.33	2.31	2.85	1.54
Middle Powder	4.59	3.03	4.80	3.32	4.83	3.27	2.24	1.91
Little Powder	5.49	3.87	5.66	4.15	5.70	3.94	3.58	2.84
Little Missouri	1.57	1.32	1.88	1.40	1.57	1.37	0.66	0.58
Antelope	8.04	3.78	8.52	4.43	8.24	4.17	3.43	2.02
Dry Fork Cheyenne	0.29	0.27	0.30	0.28	0.29	0.27	0.23	0.22
Upper Cheyenne	2.83	1.87	2.99	2.05	2.97	1.97	1.45	1.23
Lightning Creek	0.78	0.77	0.79	0.78	0.78	0.77	0.74	0.73
Upper Belle Fourche	7.08	4.90	7.60	5.17	7.29	5.06	5.28	3.99
Middle North Platte Casper	0.14	0.12	0.14	0.13	0.14	0.13	0.08	0.08
Total	4.49	2.59	4.73	2.83	4.63	2.72	2.39	1.63

On-going coal mining activities disturb vegetation at a rate of approximately 2,000 acres per year, while 1,850 acres of previously disturbed vegetation is successfully reclaimed on an annual basis. At present, approximately 54,000 acres have been disturbed by coal mining, while 20,200 acres have been successfully reclaimed. An unknown portion of disturbed coal mining area is currently undergoing reclamation, but has not yet met success standards. A similar level of both new disturbance and reclamation success is expected in the reasonably foreseeable future.

Uranium mining has resulted in the disturbance of approximately 4,400 acres, while sand, gravel, and scoria mining has resulted in the disturbance of approximately 1,200 acres. Agriculture has resulted in impacts to approximately 113,643 acres of lands formally occupied by native vegetation. Agricultural areas are not expected to substantially expand or contract in the foreseeable future. Urban development has resulted in the loss of approximately 4,362 acres of native vegetation. A minor amount of new rural and urban development is expected in the foreseeable future but no estimate of the amount or types of vegetation disturbance has been made. Cumulative impacts to vegetation from roads, railroads, and rural development have not been estimated, except where road impacts are part of existing or proposed oil and gas activities. These road impacts are included in Table 4–32 and Table 4–33.

All non-oil and gas impacts to have resulted in the loss of approximately two percent of the native vegetation in the Project Area. When non-oil and gas impacts are combined with the existing and projected impacts from oil and gas development, approximately 6.5 percent of the vegetation in the Project Area would be in a disturbed state in the short-term, and approximately four percent of the vegetation in the Project Area would be in a disturbed state in the long-term, depending on the alternative selected.

The total acreage affected by CBM development would not be disturbed simultaneously, because Project development would occur over the life of the Project. Some of the disturbed acreage would be reclaimed or would be in the process of being reclaimed when new disturbances are initiated. CBM development is expected to occur at a rate faster than abandonment and reclamation of wells. In the near future (5 to 10 years), the amount of disturbed vegetation is likely to increase, although the anticipated life of coal bed methane wells (12 to 20 years) indicates that reclamation would eventually overtake new well development, resulting in a net decrease in disturbed vegetation over the long-term.

Cumulative effects would also occur to vegetation resources as a result of indirect impacts. One factor is the potential import and spread of noxious weeds around project facilities. Noxious weeds have the ability to displace native vegetation and hinder reclamation efforts. If weed mitigation and preventative procedures were applied to all construction and reclamation practices, the impact of noxious weeds would be minimized.

In areas reclaimed after CBM development, the reclaimed areas often differ substantially from undisturbed areas in terms of vegetation cover. Reclaimed areas may not serve ecosystem functions presently served by undisturbed vegetation communities, particularly in the short term, when species composition, shrub cover, and other environmental factors would likely be different. Establishment of noxious weeds and alteration of vegetation along drainages and reclaimed areas has the potential to alter vegetation type distribution. As a result, alteration of biodiversity may occur due to the overall effects of the Project on vegetation.

Wetland/Riparian Areas

Potential effects to wetlands and riparian areas are similar to those for vegetation. In general, efforts would be made to prevent effects to wetlands and riparian areas by locating roads and facilities outside of these sensitive resources. Well pads would not be located in wetlands or riparian areas. Other facilities, particularly those of a linear nature, such as transmission lines and pipelines, would cross wetlands and riparian areas where routes that avoid these areas are not available.

Direct effects to wetlands and riparian areas would occur from the disturbance or removal of vegetation and soils in these areas resulting from the construction of transmission lines, pipelines, roads, and other facilities. Short-term effects would occur where vegetated areas are disturbed but later reclaimed within one to three years of the initial disturbance. Long-term effects would occur where roads or other semi-permanent facilities result in loss of vegetation and prevent reclamation for the life of the Project. These areas would be reclaimed during the abandonment phase, although not all roads may be reclaimed. Restoration of wetland and riparian area form and function can be difficult and may require an extended period of time. In other cases where impacts are minimal and limited in scale, restoration may occur quickly due to the availability of more water and better soils than are present in the Project Area in general.

Indirect effects to wetlands and riparian areas would occur as a result of activities other than the direct disturbance or removal of vegetation and soils. Possible indirect effects may include: 1) an increase in the potential for the spread of noxious weeds and displacement of native vegetation, due to ground disturbance in the Project Area; 2) alteration of wetland distribution and riparian area function due to changes in volume and rate of surface water flows, particularly changes in stream flow from intermittent to perennial; 3) alteration of ecosystem biodiversity due to changes in plant species composition, abundance, and distribution; and 4) changes in wildlife abundance and distribution due to changes in wetlands and riparian areas.

Alternative 1

Direct Effects

Approximately 7,306 acres (2.9 percent of the wetland/riparian areas in the Project Area) of wetland/riparian vegetation would be directly disturbed (Table 4–16 and Table 4–17) in the short-term. Direct disturbance would occur across five wetland/riparian vegetation types, including forested riparian, herbaceous riparian, shrubby riparian, water, and wet meadow. Direct disturbance of wetland/riparian vegetation would occur in ten of the 18 sub-watersheds within the Project Area (Table 4–17).

Long-term disturbance would still occur in the same vegetation types as would short-term disturbance, but the total area that remained disturbed would be less (3,534 acres or 1.4 percent of the wetland/riparian areas in the Project Area). Total long-term disturbance by land ownership type is shown in Table 4–18. Long-term disturbance would also occur in ten of the 18 sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–19. Alternative 1 would result in lower short- and long-term direct impacts to wetland/riparian areas than Alternatives 2A or 2B, but greater impacts than Alternative 3. This difference in impacts is primarily due to the different ratios of the various water handling options that would be applied under each alternative.

Produced water from CBM wells would be gathered for discharge at outfalls. Outfalls may feed into small stock reservoirs, constructed infiltration basins, or other facilities before the outflows reach surface drainages. The additional surface flows of water would directly result in the disturbance or removal of vegetation and soils. The extent of disturbance is dependent on the location chosen for discharge points, the vegetation and soils that occur downstream of the discharge, and the amount of increase in surface flows. Direct disturbance caused by surface discharge of CBM water would occur in ten of the 18 sub-watersheds within the analysis area (Tables 2-6 and 2-7).

No direct effects on wetland/riparian areas would occur as a result of the creation of containment reservoirs because they would be constructed in upland sites away from wetland/riparian areas. Infiltration reservoirs would be constructed on bottomland or upland sites. Where these reservoirs are constructed in bottomland sites, wetland/riparian areas may be impacted. The extent of these impacts cannot currently be quantified because the locations of these reservoirs have not been determined. Containment reservoirs would be constructed in upland areas, away from drainages, floodplains, and gravelly terraces, and would not be constructed as flow-through impoundments. Atomizers would be located on towers situated on floating islands in the central portions of the reservoir. Spray from these units would be directed above the water surface only, so that the land surface near the reservoir would be unaffected.

No direct effects on wetland/riparian areas would occur as a result of the creation of land application disposal (LAD) sites and/or injection facilities. These sites would be placed in upland areas away from drainages and floodplains. Water would be applied at agronomic rates at LAD sites so that there would be no runoff or infiltration of applied water that could reach surface drainages.

Following the life of the Project, facilities would be removed and their disturbed areas would be reclaimed and returned to pre-project uses. This restoration would typically include replacing salvaged topsoil, re-grading, and reseeding disturbed areas. Efforts directed toward successful reclamation of all Project disturbances would be continued until reclamation is successful.

Indirect Effects

Implementation of Alternative 1 would increase the potential for the occurrence of indirect effects to wetland/riparian areas within the Project Area. Indirect effects to wetland/riparian areas would occur in ten of the eighteen sub-watersheds. Ten out of eighteen sub-watersheds would also be indirectly affected specifically due to water discharge.

Disturbances associated with the construction of well pads, compressor stations, roads, and other facilities would provide opportunities for the invasion and establishment of noxious weeds. Noxious weeds tend to be aggressive invaders of disturbed areas, often displacing native wetland/riparian vegetation. The extent of these invasions is difficult to predict, and would be determined by many factors, including the extent of disturbed areas, the extent of existing weed infestations that would provide a seed source, the amount of equipment movement for areas infested with weeds to areas not yet infested, and the time lag between the end of disturbance and the successful completion of reclamation.

Surface discharge of produced water from CBM wells has the potential to alter vegetation patterns in areas downstream of discharge points. The shift in surface water flows would provide another type of disturbance that could be exploited by noxious weed species, as well as providing a means for the spread of noxious weeds. Noxious weeds and other aggressive species could come to dominate disturbed wetland/riparian areas, potentially reducing biodiversity in these situations.

The function of wetland and riparian areas would be altered due to changes in volume and rate of surface water flows. The increased availability of water along normally dry stream channels could cause an increase in the extent of riparian and wetland vegetation, as well as changes in stream flow from intermittent to perennial. The extent of these changes is dependent on the locations chosen for discharge points, and on the existing vegetation and soils downstream of these points.

Depending on the quality and volume of produced water, other changes in wetland/riparian vegetation may occur. In areas where the water table (i.e., shallow aquifer) rises to the surface, some plant species would not be able to grow due to saturation of the soil, thus altering the species composition of affected areas. Where continuous inundation occurs in forested riparian areas, cottonwood seedlings would not be able to become established. In other areas where the water table rises to or near the surface, cottonwood seedling establishment may increase due to increased shallow water availability.

Groundwater pumping related to CBM production is generally not expected to result in a lowered water table in shallow alluvial aquifers (see groundwater section). In some isolated locations, particularly around the edges of the Powder River Basin where the cover of the Wasatch Formation over the coal beds is thin, the groundwater table may drop. Where this drop coincides with existing wetland/riparian areas and is substantial, some wetland/riparian vegetation may be lost. The occurrence of this impact is expected to be minimal.

The quality of produced water is regulated by the NPDES permit system administered by the Wyoming DEQ. Although produced water in some areas would be of low quality, this water would be disposed of in a manner that would prevent impacts to wetland/riparian vegetation. Water that is disposed of by surface discharge or infiltration would meet DEQ water quality standards that are designed to protect aquatic life, livestock, wildlife, and other applicable water uses (such as agricultural irrigation). Because of these standards, water quality of produced water from CBM wells is not expected to have any effect on wetland/riparian areas.

There would be no indirect effects to wetland/riparian areas due to the creation of containment reservoirs, LAD sites, and/or injection wells. These sites would be placed in upland areas away from drainages and floodplains.

Alteration of biodiversity would occur due to changes in plant species composition, abundance, and distribution. Large, contiguous areas of wetland/riparian vegetation would be fragmented by the construction of roads, pipeline corridors, and other linear facilities if such areas must be disturbed. Disturbance followed by reclamation would alter the species composition of reclaimed areas when compared with undisturbed areas by replacing diverse native communities with communities consisting of a few favored reclamation species. The increase of surface water flows in riparian and wetland areas may also create an increase in biodiversity within and adjacent to disturbed areas because wetland and riparian areas tend to support a greater number of species than do adjacent uplands.

Wetland/riparian areas are important to wildlife species dependent on these types as habitat. Where the native vegetation provides an essential component of wildlife habitat, these shifts in vegetation pattern would result in decreased habitat quality for wildlife. Some of these changes in wetland/riparian vegetation would occur in areas that have been specifically identified as being important to the conservation of biological diversity.

Alternative 1 would result in potentially greater indirect impacts to wetland/riparian areas than would Alternatives 2A, 2B, or 3, because of the greater amount of surface discharge of produced water. Water that is discharged to surface drainages has a greater chance of affecting wetlands than water that is contained in reservoirs, applied directly to vegetation in upland situations, or injected. These impacts are difficult to quantify for many reasons, including variables related to the number of wells discharging into each drainage, the amount of water produced by each well, the amount of evaporation and infiltration that occurs between discharge point and wetland/riparian areas, the ability of the shallow alluvial aquifer to absorb water inputs without affecting water levels in wetland/riparian areas, and the ability of wetland/riparian vegetation to adapt to increased water availability.

Alternatives 2A and 2B

Direct Effects

Under Alternative 2, direct disturbance would be similar to Alternative 1. Within Alternative 2, two different ratios of the various water handling options (Alternatives 2A and 2B) have been analyzed. All disturbance associated with these alternatives would occur in the same vegetation types, land ownerships, and subwatersheds as Alternative 1. Table 4–20 and Table 4–24 show the direct, short-term disturbance to wetland/riparian areas by surface owner for Alternatives 2A and 2B, respectively. Table 4–21 and Table 4–25 show the direct, long-term disturbance to wetland/riparian areas by surface owner for Alternatives 2A and 2B, respectively. Table 4–22 and Table 4–26 show the direct, short-term disturbance to wetland/riparian areas by sub-watershed for Alternatives 2A and 2B, respectively. Table 4–23 and Table 4–27 show the direct, long-term disturbance to wetland/riparian areas by sub-watershed for Alternatives 2A and 2B, respectively. Total disturbance to wetland/riparian areas under Alternative 2A would encompass 7,707 acres (3.1 percent of the wetland/riparian areas in the Project Area) in the short-term and 3,935 acres (1.6 percent of the wetland/riparian areas in the Project Area) in the long-term. Total disturbance to wetland/riparian areas under Alternative 2B would encompass 7,386 acres (2.9 percent of the wetland/riparian areas in the Project Area) in the short-term and 3,614 acres (1.4 percent of the wetland/riparian areas in the Project Area) in the long-term.

The primary difference between Alternatives 1, 2A, and 2B, in terms of direct disturbance of wetland/riparian vegetation, would be in the relative proportion of disturbance caused by the different types of water disposal methods. Water handling options would directly disturb vegetation in ten of the 18 sub-watersheds within the Project Area (Tables 2-23 to 2-26). Alternative 2A would result in the greatest short- and long-term direct impacts to wetland/riparian areas when compared with Alternatives 1, 2B, and 3, while Alternative 2B would have less direct impact than Alternative 2A and more than Alternatives 1 and 3. These differences in impacts are primarily due to the different ratios of the various water handling options that would be applied under each alternative. There would be no differences in the effects of containment, LAD, or injection because these methods are only applied in upland locations, not in wetland/riparian areas. There would be fewer surface discharge locations and more infiltration reservoirs under Alternatives 2A and 2B, when compared with Alternative 1. This difference would result in greater impacts to wetland/riparian areas where these reservoirs are constructed in bottomland locations. Alternative 2A has a greater proportion of infiltration reservoirs than Alternative 2B, meaning that more wetland/riparian areas would potentially be impacted by Alternative 2A than by Alternative 2B.

Indirect Effects

Similar indirect impacts would occur to wetland/riparian areas as described under Alternative 1, although the amount of impact would be different. Both Alternative 2A and 2B would result in potentially less indirect impact to wetland/riparian areas than would Alternatives 1, but more than Alternative 3. Impacts would be reduced because of the smaller amount of surface discharge of produced water. Alternative 2B would result in the surface discharge of substantially more water than would Alternative 2A, although the total amount would still be substantially less than for Alternative 1.

Alternative 3

Direct Effects

Approximately 6,678 acres (2.7 percent of the wetland/riparian areas in the Project Area) of wetland/riparian vegetation would be directly disturbed (Table 4–28) in the short-term. Direct disturbance would occur across four wetland/riparian vegetation types, including forested riparian, shrubby riparian, water, and wet meadow. Direct short-term disturbance of wetland/riparian vegetation would occur in nine of the 18 sub-watersheds within the Project Area (Table 4–29).

Long-term disturbance would still occur in the same four vegetation types as would short-term disturbance, but the total area that remained disturbed would be less (3,202 acres or 1.3 percent of the wetland/riparian areas in the Project Area). Total long-term disturbance by land ownership type is shown in Table 4–30. Long-term disturbance would also occur in nine of the 18 sub-watersheds, but again in lesser amounts. The extent of long-term disturbance in each sub-watershed is shown in Table 4–31. Alternative 3 would result in the lowest level of short- and long-term direct impacts to wetland/riparian areas compared with Alternatives 1, 2A, or 2B. This difference in impacts is primarily due to the smaller number of wells that would be drilled under this alternative. The proportion of different water handling methods under Alternative 3 would be most similar to Alternative 1 and substantially different than Alternatives 2A and 2B (Tables 2-32 and 2-33). The greater proportion of surface discharge would potentially result in greater effects to wetland/riparian areas; however, the total potential impacts to wetland/riparian areas would be less than the three other alternatives because the total number of wells utilizing surface discharge as the water handling method would be less.

Indirect Effects

Implementation of Alternative 3 would increase the potential for the occurrence of indirect effects to wetland/riparian areas within the Project Area, although to a lesser degree than Alternatives 1 and 2. Indirect effects to wetland/riparian areas would occur in nine of the 18 sub-watersheds. Ten out of eighteen sub-watersheds would also be indirectly affected specifically due to water discharge.

No new mitigation measures (such as those that would be applied under Alternatives 1, 2A, and 2B) would be applied to wetland/riparian areas under Alternative 3 because there would be no federal action. Existing regulations that protect wetland/riparian areas, such as the Clean Water Act, would continue to be enforced. Because the additional mitigation measures discussed under the other alternatives would only apply to new wells subject to federal action and not to state or private wells, the potential for indirect effects to wetland/riparian areas from state and private wells would not change under Alternative 3. Only the potential indirect effects from federal wells would be removed.

Cumulative Effects

Implementation of the alternatives would contribute to cumulative effects on wetland/riparian areas in the Project Area. Development in wetland and riparian habitats would generally be avoided within the Project Area. Cumulative effects to wetland/riparian vegetation are included in the total effects to vegetation as shown in Table 4–32 and Table 4–33. Much of the discussion of cumulative effects to vegetation is also relevant to wetland/riparian areas. Coal, uranium, sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban development are likely to have some effect on wetland/riparian areas. Projects generally attempt to avoid wetland/riparian areas, but some types of projects, especially those that are linear in nature, cannot avoid all impacts to these sensitive resources.

As with vegetation, cumulative effects would occur to wetland/riparian resources as a result of indirect impacts. Certain types of development, including CBM development, would have the potential to alter the hydrology of riparian and wetland areas, possibly to the extent that habitat currently suitable for some plant and wildlife species would become unsuitable. Following closure and reclamation of wells, alteration of surface hydrology would cease and water regimes would return to existing conditions. The presence of noxious weeds may increase, thus displacing native vegetation and hindering reclamation efforts. As a result, changes in wetland and riparian area distribution, function, and biodiversity may occur.

Wildlife

The principal effects to terrestrial wildlife likely to be associated with the Project may include: 1) disturbance effects (including raptors, sage grouse, sharp-tailed grouse, deer, elk, antelope, and waterfowl) by human activity; 2) the loss of certain habitats, particularly big game crucial winter ranges; 3) habitat fragmentation (particularly through construction of roads and well pads); 4), the introduction of new perches for raptors and thus potential increase in local predation rates on other wildlife species; 5) an increase in hunting pressure; 6) an increase in wildlife harassment; and 7) Project-induced increases in mortality (e.g., poaching, trapping, poisoning, roadkills, raptor collision, raptor electrocution). The magnitude of effects to wildlife resources would depend on a number of factors including the recommended and required mitigation measures.

Direct disturbance of wildlife habitats would occur in each sub-watershed and under each alternative. In an effort to return habitats to wildlife use, unused portions of well sites would be reclaimed during the production phase. Following the end of the production phase, well field and ancillary facilities would be removed and disturbed areas reclaimed. Seed mixes approved by the appropriate agency, many of which are intended to be beneficial to wildlife species, would be used to revegetate abandoned well pads and areas occupied by ancillary facilities. The amount of time these lands are unsuitable as wildlife habitats is variable and may depend on one or more of the following: productive well life-span, mitigation success, reclamation techniques, and local weather conditions. Reclamation of habitats dominated by grasses and forbs is expected to be successful within several years; habitats dominated by shrubs and trees may take 8 to 20 years or more to successfully re-establish. Consequently, the disturbance of forest and shrub habitats would represent a long-term loss beyond the end of the production phase to those species that depend on such vegetation for forage or shelter. In addition, an unknown percentage of roads would not be reclaimed, resulting in permanent loss of wildlife habitats.

Indirect effects, including the displacement of wildlife, would occur in varying degrees during construction, production, and reclamation phases of the Project. In response to the increased levels of human activity, equipment operation, vehicular traffic, and noise associated with all phases of the Project, wildlife would avoid areas of these activities and utilize other locations. This avoidance would result in the under-utilization of otherwise suitable habitats; therefore the value of these habitats would be diminished. The displacement of wildlife from disturbed areas may also lead to the over-utilization of suitable habitats, increasing competition for limited resources in these areas and potentially leading to increased mortality. Additionally, wildlife distribution patterns would be altered. The degree of habitat avoidance would vary among species and among individuals of any particular species.

Mitigation measures expected to eliminate or minimize potential effects to wildlife species are provided at the end of this chapter and/or in Chapter 5 and Appendices C and D.

Alternative 1

Water handling methods under this Alternative would affect 33,808 acres in ten of the 18 watersheds within the Project Area. In total, Alternative 1 would include 213,115 and 109,922 acres of short- and long-term disturbance, respectively. In comparison, these values are less than estimates for Alternatives 2A and 2B, and more than for Alternative 3.

There are several options for handling CBM produced waters including treated surface discharge, untreated surface discharge, infiltration, impoundment, LAD, and injection. Any of these options would result in additional short- and long-term disturbance to wildlife habitats in the Project Area. Because the location of these facilities is not known, the wildlife habitats to be affected are also unknown. All of the following water handling options may directly disturb wildlife habitats within the Project Area.

Where surface discharge is selected as the water handling option, produced water from CBM wells would be gathered for surface discharge, feeding a small flow-through stock reservoir or discharging directly to a nearby surface drainage. Surface discharge associated with Alternative 1 would cause direct disturbance to 7,296 acres of wildlife habitats.

Where impoundment (i.e., no surface discharge and minimal infiltration) is selected as the water handling option, large containment reservoirs would be constructed. Impoundment associated with Alternative 1 would cause direct disturbance to 6,293 acres of wildlife habitats.

Where LAD is selected as the water handling option, disposal of CBM produced water would likely be accomplished using a disposal-rest rotation cycle consisting of disposal, soil amendment, rest, disposal, etc., until the limitations of repeated soil amendments are reached and the site reclaimed. Direct affects to wildlife habitats at LAD sites would result in direct disturbance of 1,780 acres.

Where infiltration is selected as the water handling option, infiltration impoundments of varying sizes would be constructed. Produced water from CBM wells would be gathered in each impoundment. Bore holes and trench-type excavations would enhance infiltration, and evaporation would be enhanced through the use of atomizers placed on towers situated on floating islands. Direct affects to wildlife habitats at infiltration sites would result in direct disturbance of 14,566 acres.

Where injection is selected as the water handling option, produced water from CBM wells would be gathered for injection at an injection well facility site. Direct affects to wildlife habitats at injection sites would result in direct disturbance of 3,873 acres.

Terrestrial Species

Big Game

The following text presents potential direct and indirect effects to big game within the Project Area. This information includes the identification of effect types and their potential effects to big game. Much of the following information is restricted to a qualitative analysis due to the lack of data relevant to the potential effect types and species. As an exception, existing habitat and range data were used to develop potential disturbance acres for each big game species by surface owner and sub-watershed.

Pronghorn

Direct and Indirect Effects

Direct and indirect effects to pronghorn and their ranges may occur as the result of activities proposed under Alternative 1. Direct effects resulting from construction of proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimated disturbances to each range type are presented by surface owner and sub-watershed in Table 4–34 and Table 4–35. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–36).

Table 4–34 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		BFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	39	32	0	0	17	14	14	46
Crucial Winter	0	0	0	0	0	0	0	0	0	0	0	0
Yearlong Winter	1,532	582	0	0	0	0	621	261	4,860	2,205	13,919	3,048
Winter Yearlong	4,359	1,620	17	14	1,135	491	2,693	1,122	57,572	22,609	143,025	25,856
Yearlong	13,330	5,099	39	32	9,199	3,734	12,843	4,797	114,137	43,270	325,388	56,932
Spring, Summer, Fall	102	41	17	14	0	0	11	9	969	387	2,309	451
Total	19,323	7,342	73	60	10,373	4,257	16,168	6,189	177,555	68,485	484,655	86,333

Habitat Disturbance

There are approximately seven million acres of pronghorn range in the Project Area. Direct disturbance to pronghorn ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to pronghorn ranges from project activities would result in the localized reduction of available forage and increased fragmentation of existing contiguous habitats. The concentration of potential disturbance would be variable but is not expected to result in the alteration of seasonal habitat use or herd movements of pronghorn within the Project Area.

Approximately 75,113 acres of yearlong range would be disturbed during the life of the project (e.g., long-term). This total represents the single largest total acreage for the six types of pronghorn ranges that would be disturbed under this alternative. The single largest percentage of long-term effects to pronghorn range would occur in winter range, where approximately 3,992 acres of a total 156,961 acres (three percent) would be disturbed. Pronghorn winter range occurs in the Upper, Middle, and Lower Powder River sub-watersheds and is typically dominated by sagebrush shrublands, coniferous forests, and agricultural lands. Approximately two percent of winter-yearlong and yearlong ranges would be disturbed during the life of the project. These pronghorn ranges occur throughout most of the sub-watersheds in the Project Area and are typically dominated by short- and mixed-grass prairie and sagebrush shrubland habitats. Pronghorn crucial winter-yearlong range (145 acres in Project Area) is restricted to the Middle North Platte River sub-watershed and would not be disturbed by actions proposed under Alternative 1. The loss of suitable pronghorn habitats would not likely result in adverse effects to seasonal habitat use or herd movements or condition because of the availability of suitable habitat throughout the Project Area.

Table 4–35 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed – Alternative 1

	Pronghorn Ranges (acres)													
	Severe		Crucial		Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	1,396	646	16,047	7,591	0	0	17,444	8,238
Middle Fork Powder	0	0	0	0	0	0	44	36	6	5	28	23	78	64
North Fork Powder	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Upper Powder	0	0	0	0	6,495	2,958	29,752	13,446	39,725	17,810	6	5	75,978	34,219
South Fork Powder	0	0	0	0	0	0	0	0	17	14	0	0	17	14
Salt Creek	0	0	0	0	0	0	414	161	215	109	28	23	657	293
Crazy Woman Creek	0	0	0	0	0	0	6	5	18,621	7,958	0	0	18,627	7,963
Clear Creek	0	0	0	0	0	0	3,139	1,543	16,222	7,972	0	0	19,360	9,514
Middle Powder River	0	0	0	0	297	153	0	0	4,697	2,228	1,187	551	6,181	2,932
Little Powder River	0	0	0	0	1,164	881	10,782	5,281	15,706	8,007	0	0	27,651	14,168
Little Missouri	0	0	0	0	0	0	17	14	435	356	0	0	452	370
Antelope Creek	28	23	0	0	0	0	2,165	817	43,218	16,393	0	0	45,411	17,233
Dry Fork Cheyenne	28	23	0	0	0	0	50	41	193	158	0	0	271	222
Upper Cheyenne	0	0	0	0	0	0	1,613	755	2,178	1,061	0	0	3,792	1,817
Lightning Creek	0	0	0	0	0	0	22	18	248	203	0	0	270	221
Upper Belle Fourche	0	0	0	0	0	0	26,339	13,085	10,159	5,192	0	0	36,498	18,277
Middle North Platte Casper	0	0	0	0	0	0	148	122	61	50	0	0	209	172
Total	56	46	0	0	7,956	3,992	75,887	35,970	167,755	75,113	1,249	602	252,903	115,723

Table 4–36 Pronghorn Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	186	224	2,280	2,747	2,466	2,972
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	1,362	892	5,861	3,839	7,741	5,070	14,964	9,801
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	12	11	6	5	18	16
Crazy Woman Creek	0	0	0	0	0	0	2,922	2,104	2,922	2,104
Clear Creek	0	0	0	0	556	651	2,870	3,358	3,426	4,008
Middle Powder	182	149	46	38	0	0	655	537	883	724
Little Powder	0	0	18	15	846	694	1,128	925	1,992	1,633
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	77	70	1,567	1,434	1,644	1,504
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	242	221	291	266	533	488
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	4,225	4,394	1,651	1,717	5,876	6,111
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	182	149	1,426	945	12,005	10,104	21,111	18,164	34,724	29,362

These estimates of range disturbance apply to the entire life of the project. The amount of range disturbance at any one time during project implementation would be less than these estimates, because as new areas are disturbed by development, other areas would be undergoing reclamation following development that is completed.

Habitat Fragmentation

Habitat fragmentation may occur in some suitable pronghorn habitats from the construction of project-related facilities (e.g., access roads). The extent of potential fragmentation is unknown because the precise location of project-related facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors, including current habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown at this time, it is difficult to quantify the effects of additional fragmentation. Pronghorn may avoid habitat that is otherwise suitable, depending on the extent of the fragmentation. The effects of potential fragmentation would not likely adversely affect the pronghorn because of the widespread occurrence and availability of suitable habitats throughout the Project Area.

Vehicle Collisions

Increased human activity as the result of project implementation may have several effects on pronghorn. Increased vehicle traffic is anticipated in association with the construction, production, and reclamation/abandonment phases of the Project. Quantifiable effects to pronghorn as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with pronghorn is expected to be directly correlated with the volume of traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

Pronghorn would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, pronghorn individuals would move to other adjacent suitable habitats but may encounter competition for resources. Big game sensitivity to human disturbance is difficult to quantify, and, therefore, the potential distance and duration of displacement is not known at this time. Displacement due to concentrations of human activity is not expected to cause serious detrimental effects to pronghorn because human disturbance would likely be limited temporarily and spatially, and suitable undisturbed pronghorn habitats are available and widespread throughout the Project Area.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and USFS), the State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. Pronghorn and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for pronghorn. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that pronghorn may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some pronghorn may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to pronghorn and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect pronghorn. Elevated noise levels may deter pronghorn from utilizing localized areas of suitable habitat. The effects of project-related noise levels to pronghorn would depend upon the occurrence pattern and intensity of produced noise. Pronghorn responses may vary from tolerance to avoidance of affected habitats. Due to the availability of alternate suitable pronghorn habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of pronghorn in the Project Area.

The generation and deposition of dust on suitable pronghorn forage may occur along existing and new roads within the Project Area. The accumulation of dust on suitable pronghorn forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical pronghorn range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of pronghorn individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, the total number of proposed CBM wells within pronghorn ranges is 34,724, of which more than 21,111 wells (60 percent) occur in pronghorn yearlong range. Approximately 32,685 acres would be disturbed by water handling methods under this alternative (Table 4–36).

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Project Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter*)*. The destruction of suitable pronghorn habitats following the construction of various water handling facilities may have both positive and negative effects to pronghorn. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range of individual pronghorn, which can vary between 407 and 5,683 acres (Clark and Stromberg 1987). The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. The operation of water handling facilities under this alternative may provide pronghorn and other wildlife with additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful to pronghorn. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or wildlife use, these facilities would be designed and constructed to avoid potential entrapment or drowning risks.

White-tailed Deer

Direct and Indirect Effects

Direct and indirect effects to white-tailed deer and their ranges may occur as the result of activities proposed under Alternative 1. Quantification of potential direct effects resulting from proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimated disturbances to each range are presented by surface owner and sub-watershed in Table 4–37 and Table 4–38, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–39).

Table 4–37 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	609	246	0	0	116	59	1,837	669	13,516	5,340	16,078	6,314
Winter Yearlong	39	32		0	0	0	0	0	0	32	78	64
Total	648	278	0	0	116	59	1,837	669	13,516	5,372	16,156	6,378

Table 4–38 Direct Short-term and Long-term Effects To White-tailed Deer Ranges by Sub-watershed — Alternative 1

	White-tailed Deer Ranges					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	0	0	6,339	2,983	6,339	2,983
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	0	0	4,089	1,821	4,089	1,821
South Fork Powder River	0	0	6	5	6	5
Salt Creek	0	0	0	0	0	0
Crazy Woman Creek	0	0	1,013	428	1,013	428
Clear Creek	0	0	5,033	2,433	5,033	2,433
Middle Powder River	39	32	107	53	145	84
Little Powder River	0	0	1,834	1,157	1,834	1,157
Little Missouri River	0	0	0	0	0	0
Antelope Creek	0	0	250	98	250	98
Dry Fork Cheyenne River	0	0	11	9	11	9
Upper Cheyenne River	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	180	115	180	115
Middle North Platte Casper	0	0	0	0	0	0
Total	39	32	18,895	9,129	18,933	9,160

Table 4–39 White-tailed Deer Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0
Upper Tongue River	863	1040	863	1,040
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder River	806	528	806	528
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	156	112	156	112
Clear Creek	881	1,031	881	1,031
Middle Powder	18	15	18	15
Little Powder	72	59	72	59
Little Missouri	0	0	0	0
Antelope	9	8	9	8
Dry Fork Cheyenne	0	0	0	0
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	19	20	19	20
Middle N Platte Casper	0	0	0	0
Total	2,824	2,813	2,824	2,813

Habitat Disturbance

There are approximately 765,647 acres of white-tailed deer range in the Project Area. Direct disturbance to white-tailed deer ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to white-tailed deer ranges from Project activities would result in the localized reduction of available forage. The concentration of potential disturbance would be variable but is not expected to result in the alteration of seasonal habitat use or herd movements of white-tailed deer within the Project Area.

An estimated 9,160 acres of white-tailed deer winter yearlong and yearlong ranges would be directly disturbed under this alternative. Approximately 9,129 acres of yearlong range would be disturbed during the life of the Project (e.g., long-term), accounting for approximately 99 percent of the total disturbance to white-tailed deer ranges in the Project Area. White-tailed deer yearlong range occurs in nearly all of the sub-watersheds included within the Project Area. White-tailed deer yearlong range is typically associated with stream and river bottoms and dominated by wet meadow, and short- and mixed-grass prairie. Less than one percent of white-tailed winter yearlong range would be disturbed under this alternative. This range occurs in the Middle Powder River sub-watershed and is dominated by short- and mixed-grass prairie, coniferous forest, and wet meadow. No white-tailed deer crucial winter range was identified within the Project Area. The total estimate of long-term disturbance to white-tailed deer ranges is 9,160 acres, or approximately 14 percent of the total available white-tailed deer range within the Project Area. The loss of suitable white-tailed deer habitats would not likely result in adverse effects to seasonal habitat use, herd movements or herd condition because of the availability of suitable habitat throughout the Project Area.

These estimates of range disturbance include the entire life of the Project. The amount of range disturbance at any one time during project implementation would be less than these estimates, due to the phased nature of development (i.e., as new areas are disturbed by development, other areas would be undergoing reclamation).

Habitat Fragmentation

Habitat fragmentation may occur in some suitable white-tailed deer habitats from the construction of project-related facilities (e.g., access roads). The intensity of potential fragmentation is unknown because the precise location of project facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors, including current habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown, it is difficult to quantify the effects of additional fragmentation. White-tailed deer may avoid habitat that is otherwise suitable, depending on the extent of fragmentation.

Vehicle Collisions

Increased vehicle traffic within the Project Area would likely result in an increased frequency of vehicle collisions with big game and other wildlife. Quantifiable effects to white-tailed deer as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with white-tailed would be correlated with the volume and frequency of vehicle traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

White-tailed deer would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, white-tailed deer would move to other adjacent suitable habitats. Big game sensitivity to human disturbance is difficult to quantify, nonetheless, compared to other big game species, white-tailed deer are less sensitive to temporary or short-term human activities, and therefore, the potential distance and duration of displacement is expected to be more than other big game species. Displacement due to concentrations of human activity are not expected to cause detrimental effects to white-tailed deer because human disturbance would likely be limited temporarily and spatially, and suitable white-tailed deer habitats are available.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and USFS), State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. White-tailed deer and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for white-tailed deer. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that white-tailed deer may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some white-tailed deer may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to white-tailed deer and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect white-tailed deer. Elevated noise levels may deter white-tailed deer from utilizing localized areas of suitable habitat. The effects of Project-related noise levels to white-tailed deer would depend upon the occurrence pattern and intensity of produced noise. White-tailed deer responses may vary from tolerance to avoidance of local habitats. Due to the availability of alternate suitable white-tailed deer habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of white-tailed deer in the Project Area.

The generation and deposition of dust on suitable white-tailed deer forage may occur along existing and new access roads within the Project Area. The accumulation of dust on suitable white-tailed deer forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical white-tailed deer range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of white-tailed deer individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, the total number of proposed CBM wells within white-tailed deer ranges is 2,824, of which more than all occur within white-tailed deer yearlong range. No proposed wells, under this alternative occur in winter yearlong range. Approximately 2,813 acres would be disturbed by water handling methods under this alternative (Table 4–39).

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Project Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable white-tailed deer habitats following the construction of various water handling facilities may have both positive and negative effects to white-tailed deer. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range (approximately 19 acres; Fitzgerald et al., 1994). The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. Some methods of water handling facilities under this alternative may provide white-tailed deer and other wildlife additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful. Existing water availability conditions would influence the potential for big game concentrations to occur or increase at newly constructed water handling facilities. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or other wildlife use, these facilities would be designed and constructed to avoid potential entrapment or drowning risks.

Mule Deer

Direct and Indirect Effects

Direct and indirect effects to mule deer and their ranges may occur as the result of activities proposed under Alternative 1. Direct effects resulting from construction of proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed but were not available by surface owner. Estimated disturbances to each range type are presented by surface owner and sub-watershed in Table 4–40 and Table 4–41.

Table 4–40 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6.321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–41 Direct Short-term and Long-term Effects to Mule Deer Ranges by Sub-watershed — Alternative 1

	Mule Deer Ranges					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	18,025	8,447	1,101	1,090	19,126	9,537
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	56,803	25,109	29,272	10,742	86,075	35,851
South Fork Powder River	0	0	6	5	6	5
Salt Creek	985	357	144	1,369	1,129	1,726
Crazy Woman Creek	11,869	4,183	4,689	1,724	16,558	5,907
Clear Creek	14,817	5,245	2,884	1,708	17,701	6,953
Middle Powder River	4,531	2,031	1,394	508	5,925	2,539
Little Powder River	3,095	1,093	13,324	5,215	16,419	6,308
Little Missouri River	0	0	0	0	0	0
Antelope Creek	770	279	20,789	7,293	21,559	7,572
Dry Fork Cheyenne River	0	0	11	9	11	9
Upper Cheyenne River	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	11,873	4,260	11,873	4,260
Middle North Platte Casper	0	0	0	0	0	0
Total	110,895	46,743	86,596	34,356	197,491	81,099

Habitat Disturbance

There are approximately 7,193,380 acres of mule deer range in the Project Area, including winter yearlong, yearlong, and spring/summer/fall ranges. Direct disturbance to the various types of mule deer ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to mule deer ranges from Project activities would result in the localized reduction of available forage and increased fragmentation of existing contiguous habitats.

The concentration of potential disturbance would be variable but is not expected to result in the alteration of seasonal habitat use or herd movements of mule deer within the Project Area.

Approximately 81,099 acres of mule deer range would be disturbed during the life of the Project (e.g., long-term). Approximately 46,743 acres of disturbance would occur in mule deer winter yearlong range that represents approximately 58 percent of the total disturbance. Mule deer winter yearlong range occurs in most sub-watersheds within the Project Area, except the Upper Belle Fourche River and Upper Cheyenne River sub-watersheds and is typically dominated short- and mixed-grass prairie, sagebrush shrubland, and other shrubland. Approximately two percent of winter-yearlong would be disturbed during the life of the Project. Approximately 34,356 acres, or one percent, of mule deer yearlong range would be disturbed during the life of the Project. Mule deer yearlong range occurs in nearly all of the sub-watersheds throughout the Project Area and is typically dominated by short-grass prairie, sagebrush shrublands, and mixed-grass prairie. Mule deer spring/summer/fall range (127,819 acres in Project Area) is restricted to the Middle Fork Powder River sub-watershed and would not be disturbed by actions proposed under Alternative 1. The loss of suitable mule deer habitats would not likely result in adverse effects to seasonal habitat use or herd movements or condition because of the availability of suitable habitat throughout the Project Area.

These estimates of range disturbance apply to the entire life of the Project. The amount of range disturbance at any one time during project implementation would be less than these estimates, because as new areas are disturbed by development other areas would be undergoing reclamation following development that is completed.

Habitat Fragmentation

Habitat fragmentation may occur in some suitable mule deer habitats from the construction of project-related facilities (e.g., access roads). The extent of potential fragmentation is unknown because the precise location of project-related facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors including existing habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown at this time, it is difficult to quantify the effects of additional fragmentation. Mule deer may avoid habitat that is otherwise suitable, depending on the extent of fragmentation. The effects of potential fragmentation would not likely adversely affect the mule deer because of the widespread occurrence and availability of suitable habitats throughout the Project Area.

Vehicle Collisions

Increased human activity as the result of project implementation may have several effects on mule deer. Increased vehicle traffic is anticipated in association with the construction, production, and reclamation/abandonment phases of the Project. Quantifiable effects to mule deer as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with mule deer is expected to be directly correlated with the volume of traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

Mule deer would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, mule deer would move to other adjacent suitable habitats. Big game sensitivity to human disturbance is difficult to quantify, nonetheless, compared to some other big game species, mule deer are less sensitive to temporary or short-term human activities, and therefore, the potential distance and duration of displacement is expected to be more than other big game species. Displacement due to concentrations of human activity are not expected to cause detrimental effects to mule deer because human disturbance would likely be limited temporarily and spatially, and suitable mule deer habitats are available.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and USFS), the State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. Mule deer and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for mule deer. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that mule deer may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some mule deer may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to mule deer and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect mule deer. Elevated noise levels may deter mule deer from utilizing localized areas of suitable habitat. The effects of Project-related noise levels to mule deer would depend upon the occurrence pattern and intensity of produced noise. Mule deer responses may vary from tolerance to avoidance of affected habitats. Due to the availability of alternative suitable mule deer habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of mule deer in the Project Area.

The generation and deposition of dust on suitable mule deer forage may occur along existing and new roads within the Project Area. The accumulation of dust on suitable mule deer forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical mule deer range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of mule deer individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, the total number of proposed CBM wells within mule deer ranges is 17,628, of which more than 14,804 wells (84 percent of total) would occur in mule deer winter yearlong range. A total of approximately 14,027 acres would be disturbed in mule deer winter yearlong (14,804 acres) and yearlong (2,813 acres) by water handling methods under this alternative (Table 4–42).

Table 4–42 Mule Deer Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Yearlong		Winter Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0
Upper Tongue River	863	1,040	2,589	3,120	3,452	4,160
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder River	806	528	11,496	7,530	12,302	8,058
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	28	0	0
Crazy Woman Creek	156	112	0	0	156	112
Clear Creek	881	1,031	0	0	881	1,031
Middle Powder	18	15	688	564	706	579
Little Powder	72	59	0	0	72	59
Little Missouri	0	0	0	0	0	0
Antelope	9	8	0	0	9	8
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	19	20	0	0	19	20
Middle N Platte Casper	0	0	0	0	0	0
Total	2,824	2,813	14,804	11,242	17,628	14,027

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Project Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable mule deer habitats following the construction of various water handling facilities may have both positive and negative effects to mule deer. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range of individual mule deer. The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. The operation of water handling facilities under this alternative may provide mule deer and other wildlife additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful. Existing water availability conditions would influence the potential for big game concentrations to occur or increase at newly constructed water handling facilities. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or wildlife use, these facilities would be designed and constructed to avoid potential or drowning risks.

Elk

Direct and Indirect Effects

Direct and indirect effects to elk and their ranges may occur as the result of activities proposed under Alternative 1. Direct effects resulting from construction of proposed CBM wells, compressors, non-CBM wells, and associated water handling methods were estimated by applying facility-specific disturbance factors to the proposed number of each facility type. These facility-specific disturbances were then summed and used to estimate the potential number of acres disturbed for each range type. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed but were not available by surface owner.

This analysis is restricted to elk and elk ranges that occur within the Fortification Creek Area in the Upper Powder River sub-watershed. This area contains several overlapping elk ranges and is expected to experience disturbance from the construction and operation of CBM wells, non-CBM wells, compressors, and water handling facilities. Additional elk ranges exist along the southern and western boundaries of the Project Area, outside of Fortification Creek, but are expected to be disturbed only by the construction of non-CBM wells. Estimates of total disturbance in these ranges outside of Fortification Creek are less than 300 acres out of approximately 610,000 acres of range. The level of disturbance to elk and their ranges outside of Fortification Creek would not likely result in detrimental effects to seasonal habitat use, herd movements or herd condition because of the availability of remaining undisturbed habitat throughout the Project Area. Estimated disturbances to each range type within Elk Fortification Creek are presented by surface owner and sub-watershed in Table 4–43, Table 4–44, Table 4–45, and Table 4–46.

Table 4–43 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	50	41	28	23	39	32	6	5	132	108	254	208
Crucial Winter Yearlong	11	9	0	0	0	0	17	14	17	14	44	36
Crucial Winter	11	9	0	0	0	0	11	9	33	27	55	45
Spring, Summer, Fall	6	5	0	0	0	0	0	0	11	9	17	14
Winter	0	0	0	0	0	0	0	0	17	14	17	14
Winter Yearlong	11	9	0	0	11	9	0	0	28	23	50	41
Total	89	73	28	23	50	41	33	27	237	194	599	357

Table 4–44 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 1

	Elk Ranges (acres)													
	Crucial Winter		Yearlong		Crucial Winter Yearlong		Spring, Summer, Fall		Winter		Winter Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	5	0	0	0	0	0	0	0	0	6	5	6	5
Middle Fork Powder River	0	0	44	36	11	9	0	0	0	0	55	45	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	6	5	0	0
Upper Powder River	0	0	0	0	0	0	0	0	0	0	39	32	0	0
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	6	5	0	0
Salt Creek	0	0	0	0	0	0	0	0	0	0	28	23	0	0
Crazy Woman Creek	0	0	0	0	0	0	6	5	0	0	6	5	0	0
Clear Creek	0	0	0	0	6	5	11	9	0	0	17	14	0	0
Middle Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0	6	5	55	45	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	0	0	17	14	94	77	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	0	0	0	0	0	11	9	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	5	44	36	17	14	17	14	22	18	319	261	6	5

Table 4–45 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 1

	Surface Owner (acres)											
	BLM											
	Buffalo FO		Casper FO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	3,540	1,276	0	0	0	0	675	245	3,870	2,916	8,085	2,916
Parturition	1,416	514	0	0	0	0	342	125	1,534	1,194	3,292	1,194
Winter Yearlong	1,948	702	0	0	0	0	446	162	2,125	1,634	4,519	1,634
Crucial Winter Range	467	170	0	0	0	0	215	78	1,308	724	1,990	724

Table 4–46 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 1

	Elk Ranges (acres)							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Upper Powder River	9,531	4,364	3,875	1,776	5,324	2,438	2,338	1,072
South Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	9,531	4,364	3,875	1,776	5,324	2,438	2,338	1,072

Habitat Disturbance

There are approximately 122,931 acres of elk range in the Fortification Creek Area. Several ranges occur in Fortification Creek and overlap over the same habitats. Because of this overlapping nature, it is not appropriate to sum the totals of each range to estimate the total acres of range within this area. Although elk ranges in this area overlap, they are not precisely concentric. Crucial winter, parturition, winter yearlong and yearlong ranges occur in Fortification Creek. Direct disturbance to elk ranges would result from construction of well pads, compressor stations, associated utility corridors, access roads and water handling features, as outlined in Chapter 2 of this document. Disturbance to elk ranges from project activities would result in the localized reduction of available forage and increased fragmentation of existing contiguous habitats which may have varying effects depending time of year.

If evaluated by percentage of potential disturbance to each range type within Fortification Creek, the greatest estimated disturbance to a single range type is 4 percent disturbance to yearlong range (4,364 acres of disturbance in 122,931 acres). Each of the other ranges would experience 3 percent disturbance during the life of the project (e.g., long-term). Sagebrush shrublands, short- and mixed-grass prairie, agriculture, and herbaceous riparian areas typically dominate these ranges. Elk yearlong range occurs in nearly all of the sub-watersheds throughout the Project Area and is typically dominated by short-grass prairie, sagebrush shrublands, and mixed-grass prairie.

These estimates of range disturbance apply to the entire life of the project. The amount of range disturbance at any one time during project implementation would be less than these estimates, due to the phased nature of development (i.e. as new areas are disturbed by development, other areas would be undergoing reclamation following development that is completed).

Habitat Fragmentation

Habitat fragmentation may occur in some suitable elk habitats from the construction of project-related facilities (e.g., access roads). The extent of potential fragmentation is unknown because the precise location of project-related facilities is undetermined at this time. The potential effects of habitat fragmentation are dependent upon several factors, including existing habitat condition and fragmentation, proximity of additional suitable habitats, degree of proposed disturbance and fragmentation, and local population size. Because these determinant factors are largely unknown at this time, it is difficult to quantify the effects of additional fragmentation. Potential fragmentation of habitats in the Fortification Creek Area may effect elk over various seasons due to the overlapping nature of ranges in this area. Elk may avoid habitat that is otherwise suitable, depending on the extent of fragmentation. The effects of potential fragmentation would likely be mitigated by implementing the measures and stipulations provided in Chapter 5 and Appendices C and D of this document.

Vehicle Collisions

Increased human activity as the result of project implementation may have several effects on elk. Increased vehicle traffic is anticipated in association with the construction, production, and reclamation/abandonment phases of the Project. Quantifiable effects to elk as the result of increased vehicle traffic are not available; however, the potential for vehicle collisions with elk is expected to be directly correlated with the volume of traffic. Project-related traffic volumes are expected to be greatest during the construction phase and gradually diminish in the production and reclamation/abandonment phases.

Human Disturbance

Elk would potentially be temporarily displaced from suitable habitats in areas of concentrated human activity. Displacement would likely be dependent on the activity duration and intensity (i.e., drill rig operations versus survey work). When displaced, elk would move to other adjacent suitable habitats. Big game sensitivity to human disturbance is difficult to quantify, nonetheless, compared to some other big game species, elk are less sensitive to temporary or short-term human activities, and therefore, the potential distance and duration of displacement is expected to be more than other big game species. Displacement due to concentrations of human activity are not expected to cause detrimental effects to elk because human disturbance would likely be limited temporarily and spatially, and suitable elk habitats are available.

Diversion from Public to Privately Owned Lands

Project actions are proposed for lands owned by public agencies (e.g., BLM and FS), the State of Wyoming, and individual private owners. The majority of human activity associated with the Project would occur on privately owned lands, with relatively little development of publicly owned lands. Elk and other wildlife utilize suitable habitats despite ownership boundaries. No known distribution information relevant to land ownership is available for elk. It is possible in areas that receive relatively high hunting pressure on publicly owned lands, that elk may prefer suitable habitats on privately owned lands and temporarily avoid otherwise suitable habitats on publicly owned lands. Under such an assumption and if project activities occur in sufficient densities on privately owned lands, some elk may not prefer habitats on privately owned lands and thus remain on publicly owned lands. Issues relating to elk and other wildlife occurrence patterns on lands of different ownership (e.g., privately owned versus publicly owned) and the potential effects from project activities are speculative due to the undetermined density and local pattern of project activities, including the effects of new access roads. The effects from new access roads is difficult to quantify because road densities and lengths are dependent upon specific facility locations, which are undetermined at this time.

Noise and Dust

Elevated noise levels associated with increased human activity and facility operations may affect elk. Elevated noise levels may deter elk from utilizing localized areas of suitable habitat. The effects of Project-related noise levels to elk would depend upon the occurrence pattern and intensity of produced noise. Elk responses may vary from tolerance to avoidance of affected habitats. Due to the availability of alternative suitable elk habitats throughout much of the Project Area, localized elevated noise levels are not expected to result in decreased condition or an increased mortality rate of elk in the Project Area.

The generation and deposition of dust on suitable elk forage may occur along existing and new roads within the Project Area. The accumulation of dust on suitable elk forage would likely be limited to habitats immediately adjacent to unimproved roads and represent a relatively small fraction of the total available forage within a typical elk range. The loss of potential forage due to the accumulation of dust would not affect the survivability or condition of elk individuals or populations.

Water Handling

The proportion of different water handling methods varies across sub-watersheds (refer to Chapter 2 for details). The number of proposed CBM wells by alternative can be used to estimate the associated disturbance to big game ranges by water handling methods. Under Alternative 1, more CBM wells (2,209) are proposed in elk yearlong range in the Fortification Creek Area, than any other range type. These wells would account for approximately 1,447 acres of disturbance. Table 4–47 presents the estimated disturbance to elk ranges in Fortification Creek from water handling methods.

Table 4–47 Elk (Fortification Creek only) Water Handling Disturbance Acres by Sub-watershed — Alternative 1

	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	2,209	1,447	888	582	1,228	804	532	348
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder	0	0	0	0	0	0	0	0
Little Powder	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle N Platte Casper	0	0	0	0	0	0	0	0
Total	2,209	1,447	888	582	1,228	804	532	348

Construction of water handling facilities would likely occur in upland situations; however, the exact location and habitat type for these facilities is currently undetermined. Because sagebrush shrublands and short- and mixed-grass habitats are the most common and widely distributed habitat types within the Fortification Creek Area, it is assumed these habitat types would experience the majority of disturbance associated with the construction of water handling facilities (refer to the vegetation section of this chapter). The destruction of suitable elk habitats following the construction of various water handling facilities may have both positive and negative effects to elk. The loss of suitable habitats due to the construction of water handling facilities would not limit the occurrence or availability of these habitats over the home range of individual elk. The relative amount of habitat loss would be outweighed by the availability and widespread occurrence of suitable habitat throughout the Project Area. The operation of water handling facilities under this alternative may provide elk and other wildlife additional drinking water resources and may increase the amount of forage available in wetland and riparian areas that expand in response to surface discharge of produced water. As fully described in Chapter 2, water quality is strictly controlled by the NPDES permitting process. Water that may be available to wildlife and livestock would meet all NPDES permitting requirements and, therefore, would not be expected to be harmful. Existing water availability conditions would influence the potential for big game concentrations to occur or increase at newly constructed water handling facilities. The distribution of existing water resources combined with the distribution of new water handling facilities would not result in concentrations of big game or other wildlife to the extent that it would be detrimental to wildlife (e.g., disease vectors) or wildlife habitats. Although water handling facilities would not be specifically intended for big game or wildlife use, these facilities would be designed and constructed to avoid potential entrapment or drowning risks.

Moose

Under Alternative 1, proposed well pads, compressors, and other facilities would not affect any of the five moose ranges that occur in the Project Area (Figure 3–14).

Raptors

<u>Direct and Indirect Effects</u>

Several raptor species may occur in the Project Area and these raptors have diverse habitat and prey species preferences. Collectively, habitat disturbance due to project-related activities may result in the loss of suitable raptor nesting and wintering habitats and the loss of preferred prey species habitats and possible reductions in prey base numbers. Quantification of potential losses is directly associated with expected losses by vegetation type. This information is presented in the Vegetation section of this Chapter. Ground-nesting raptors are likely to experience the most substantial direct loss of suitable nesting habitats. Cliff and tree-nesting raptors are less likely to experience loss of suitable nesting substrates because these habitats are not expected to be directly affected by the proposed actions. Wintering roosts used by bald eagles and other wintering raptors would not be expected to be directly impacted because several mitigation measures institute surface disturbance buffers and timing restrictions (refer to Chapter 5 and Appendix C).

<u>Human Disturbance</u>

Human disturbance may result in effects to raptors in the Project Area. Human disturbances during the life of the Project may vary by type and intensity ranging from one-time pedestrian surveys of development areas, well pad construction and well development, to regular maintenance trips to wells. Raptors have been known to become accustomed to some human activities, particularly activities that occur regularly and predictably. However, in some cases, particularly nesting and wintering roosts, raptors may exhibit particular sensitivities to nearby human activities, regardless of the activity and its intensity. Disturbance to nesting raptors can cause nest failure, nest abandonment, and unsuccessful fledging of young. Measures to mitigate these potential effects, including timing restrictions and surface disturbance buffer zones, are presented in Chapter 5 and Appendix C of this document. The implementation of these measures is expected to reduce the effects of human disturbance to nesting and wintering raptors and preclude any effects to local breeding or wintering raptor populations.

Increased Perch Availability and Use

As part of the proposed Project, utility lines would be constructed above- and below-ground. Aboveground power lines and support structures would be used to provide power to individual well pods. From centralized pods, power would be distributed using underground lines. Support structures associated with aboveground power lines are expected to be used as perches by raptors. These perches may provide raptors with new opportunities for hunting and capturing prey. This benefit is expected to be temporary because if new perch sites actually increase hunting success, the number and density of prey species may eventually decrease due to increased hunting pressure. This would then be the limiting factor to raptor populations.

Raptor Collisions and Electrocutions

The presence of new aboveground power lines may increase the potential for raptor collisions and electrocutions. All aboveground support structures would be equipped with APLIC-approved devices intended to prevent and reduce the risk of electrocution to perching raptors. Other APLIC recommendations for line spacing and distribution may be used to minimize potential avian collisions. Power lines from individual well pods to the facilities within each pod would be constructed underground. These lines are expected to account for the majority of the new lines constructed during the life of the Project.

Increased vehicular traffic may result in increased collisions with raptors. Raptor collisions with vehicles are often associated with carrion-feeding raptors along high-speed roadways. Because project-related activities are expected to increase commercial and private traffic levels on public highways within the Project Area, the potential for raptor collision along these existing highways is expected to increase. The increase in vehicle collisions with individual raptors is not expected to contribute to the loss of raptor population viability or health. Due to the unimproved nature of the existing and proposed access roads, vehicle speeds are not expected to be similar to highway speeds and, therefore, vehicle collisions with raptors would not expected to be common. Any potential collisions with raptors along secondary or unimproved access roads would not be expected to result in detrimental changes in local raptor populations.

Prey Availability

The diverse raptor population that occurs in the Project Area relies upon a wide variety of prey species that utilize many different habitats. Quantification of potential reduction in prey populations as the result of Project activities can only be evaluated by reviewing the potential losses by vegetation type. Prey species, particularly small- and medium-sized mammals, may experience losses due to direct mortality and/or loss of habitat. These potential losses are not expected to result in detrimental effects to local prey populations or to locally occurring raptors. In some instances, particularly with water handling methods, local habitat conditions may improve from the increased water availability and, in turn, benefit local prey species and their dependent predators, including raptors. These benefits may be considered non-permanent, because any improved water availability conditions are expected to return to pre-project levels following the life of the Project. Local prey species may experience a temporary shift in population levels, while population numbers respond to new environmental conditions. These potential population shifts are not expected to be detrimental to the survivability or fitness of these populations and would not have detrimental impacts to local raptor species populations.

Water Handling

Water handling methods would most likely affect prey habitats and, subsequently, prey population numbers, but water handling methods would not likely directly affect raptors or their habitats. Potential adverse effects of water handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium-sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scale relevant to predatory species, including raptors. Potential effects to raptors from water handling methods are expected to be limited to indirect effects, due to potential changes to habitats. For more information regarding potential effects to habitats refer to the vegetation section of this chapter.

Upland Game Birds

Effect types and potential impacts to sage grouse and plains sharp-tailed grouse are expected to be similar. Because these species also share similar habitats and behavior, this analysis of potential effects and impacts will address both species.

Direct and Indirect Effects

Habitat disturbance due to project-related activities may result in the direct disturbance or loss of important breeding grounds (leks) and brood rearing habitats. To avoid direct disturbance to leks, data regarding lek location and seasonal use would be reviewed before initiating ground surface disturbance. Mitigation measures listed at the end of this chapter and stipulations provided in Chapter 5 and Appendix C would be applied to avoid direct disturbance to leks. Habitat disturbance to brood-rearing habitats (riparian areas) and feeding and resting areas (sagebrush shrublands) would be expected during the life of the Project. Disturbances to riparian areas would be minimal in nature due to the intent to avoid disturbance to these areas and the implementation of several measures to limit disturbance in cases when riparian areas would be disturbed (see wetland/riparian section in this chapter). Short-term disturbance to sagebrush shrublands would occur over approximately 86,000 acres within the Project Area. This accounts for approximately four percent of the available sagebrush vegetation type within the Project Area (2,234,129 acres). The potential impacts to sage grouse would be dependent upon the pattern of development and how the development fragments patches of suitable sagebrush shrubland at a scale relevant to sage grouse. It would be expected that sagebrush shrubland habitats of sufficient size and quality would be available for sage grouse in most scenarios of development.

Human Disturbance

Human disturbance associated with project-related activities, including noise from Project facilities, may result in adverse effects to sage grouse. Sage grouse are most sensitive to human activity and noise when on their seasonal breeding grounds (leks). Although human activities may disturb individually nesting sage grouse, possible effects to groups of grouse on their breeding grounds would be expected to have greater potential to affect local populations of this species. Mitigation measures listed at the end of this chapter and stipulations provided in Chapter 5 and Appendices C and D would be applied to avoid disturbance to sage grouse on leks. These efforts would be expected to minimize disturbance to sage grouse on their leks and, therefore, reduce the potential for detrimental effects to local sage grouse populations.

Predation by Raptors

As a possible outcome of implementing the proposed Project, raptor species may benefit from the increased availability of hunting perches from the installation of aboveground power lines. The availability of these perches may result in increased raptor hunting pressures on sage grouse, particularly when grouse are on the leks. Lek abandonment has been documented where power lines are within ½ mile and visible from the lek. Sage grouse have also been documented avoiding otherwise suitable habitats within ½ mile of power lines (San Miguel Basin Sage Grouse Working Group 1998).

Collisions

Sage grouse collisions with vehicles and aboveground power lines may increase due to project-related activities. Vehicle traffic patterns are expected to increase over current patterns and fluctuate by intensity and frequency during the life of the Project. These changes may increase the potential for collisions with sage grouse and other wildlife species.

Water Handling

Under this alternative, water-handling methods may have positive and negative effects to the sage grouse. Production waters from outflows or surface discharge water handling practices may supplement existing or create new wetland and riparian habitats. These new habitats would provide additional brood-rearing habitats for sage grouse. Water impoundments and increased water flows would also provide additional drinking water sources for sage grouse. The construction of water handling facilities would result in the loss of sagebrush shrublands that are used as nesting habitat by this species. Additional losses of sagebrush may occur from the LAD method for production water. A summary of losses by habitat type, including contributions from water handling methods are presented in the vegetation section of this chapter.

Waterfowl

Habitat Disturbance

Habitat disturbance as the result of applied water handling methods would result in a variety changes, including possible negative and positive effects to waterfowl habitats. Water from surface impoundment outflows and direct surface discharge may create new and improve existing feeding, nesting, and resting habitats, by supplementing current seasonal water regimes. These potential changes would occur in naturally existing terrain conditions and not associated with surface containment facilities. Surface containment facilities may also provide new feeding, nesting, and resting habitats to local waterfowl.

Production water from surface outflows and direct surface discharge may also negatively affect existing waterfowl habitats. Dependent upon specific site conditions, inputs to existing aquatic habitats from production water may alter favorable conditions to the detriment of plants and aquatic life. These potential effects are dependent upon existing conditions, quantity, and timing of the release of production waters, and distance between release points and existing waterfowl habitats. Although these potential effects are possible, they are not expected to detrimentally affect the survivability or condition of local regional waterfowl populations.

Exposure to Production Water

Concentrations of salts and metals, particularly barium, are expected to increase in the waters of the containment reservoirs as water evaporates over time. Such concentrations have not yet been predicted quantitatively, so precise descriptions of direct and indirect effects to waterfowl are not possible at this time. It is speculated that indirect effects (e.g., changes to waterfowl foods and nesting cover) are likely to be more important than direct effects (i.e., toxicity) to waterfowl. Salinity limits and optimum ranges for microbial communities, algae, and aquatic invertebrates are known for many species and can be found in the scientific literature (Adamus 1996). It is presumed that the containment reservoirs will be colonized by species of these taxa that are tolerant of the excessively saline water quality conditions relative to surrounding water bodies.

The species richness of microbial communities and aquatic invertebrates, as well as algal productivity and biomass, can be expected to be less in the containment reservoirs than less-saline local water bodies based on a number of scientific studies (Adamus 1996). As the salinity increases over time and as water evaporates from the containment reservoirs, these bioindicators will evidence a negative correlation. Similarly, the species richness and abundance of waterfowl is expected to be low and less than surrounding unaffected water bodies.

The direct effects to waterfowl from increasing concentrations of metals in the containment reservoirs cannot be well surmised without quantitative predictions of the concentrations. Selenium levels in the water column of greater than 0.050 mg/L are considered to pose a potential risk to many waterbird species, due to the element's known toxicological effects and high bioaccumulation potential in food chains. The saline quality of the water is expected to cause precipitation of dissolved metals in the water column, such that sediments will receive increasing concentrations of organic and inorganic forms of the metals contained in the CBM-produced waters over time. It is possible that eventually the sediments may reach a toxic level for diving ducks that ingest sediments while feeding on benthic organisms. Changes in algal and microbial species richness that could cause indirect effects on waterfowl may or may not occur in response to increasing metals concentrations (Adamus 1996).

Alternative 2A

Alternative 2A is similar to Alternative 1 in the type and magnitude of disturbance associated with the project. However, Alternative 2A does differ in the proportions assigned to the various water handling methods. Under this alternative, as compared to Alternative 1, there would be an increased emphasis on the use of infiltration, containment reservoirs, and LAD; and a decreased emphasis on the use of surface discharge. These differences in water handling would result in variations of habitat disturbance and would not be expected to have unique or different effect types from those presented under Alternative 1.

Terrestrial Species

Big Game

Pronghorn

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–48 and Table 4–49 present estimates of disturbance to range by surface owner and sub-watershed. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–50). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–48 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	39	32	0	0	17	14	14	46
Crucial Winter Yearlong	0	0	0	0	0	0	0	0	0	0	0	0
Winter	1,532	582	0	0	0	0	621	261	4,860	2,205	13,919	3,048
Winter Yearlong	4,359	1,620	17	14	1,135	491	2,693	1,122	57,572	22,609	143,025	25,856
Yearlong	13,330	5,099	39	32	9,199	3,734	12,843	4,797	114,137	43,270	325,388	56,932
Spring, Summer, Fall	102	41	17	14	0	0	11	9	969	387	2,309	451
Total	19,323	7,342	73	60	10,373	4,257	16,168	6,189	177,555	68,485	484,655	86,333

Table 4–49 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed – Alternative 2A

	Disturbance (acres)													
	Severe Winter		Crucial Winter		Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	1,457	707	16,788	8,332	0	0	18,245	9,039
Middle Fork Powder	0	0	0	0	0	0	44	36	6	5	28	23	78	64
North Fork Powder	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Upper Powder	0	0	0	0	7,380	3,843	33,562	17,256	44,757	22,842	6	5	85,705	43,946
South Fork Powder	0	0	0	0	0	0	0	0	17	14	0	0	17	14
Salt Creek	0	0	0	0	0	0	423	170	220	114	28	23	671	307
Crazy Woman Creek	0	0	0	0	0	0	6	5	20,988	10,325	0	0	20,994	10,330
Clear Creek	0	0	0	0	0	0	3,339	1,743	17,255	9,005	0	0	20,594	10,748
Middle Powder River	0	0	0	0	321	177	0	0	5,038	2,569	1,282	646	6,640	3,391
Little Powder River	0	0	0	0	1,173	890	11,222	5,721	16,293	8,594	0	0	28,687	15,204
Little Missouri	0	0	0	0	0	0	17	14	435	356	0	0	452	370
Antelope Creek	28	23	0	0	0	0	2,165	817	43,218	16,393	0	0	45,411	17,233
Dry Fork Cheyenne	28	23	0	0	0	0	50	41	193	158	0	0	271	222
Upper Cheyenne	0	0	0	0	0	0	1,613	755	2,178	1,061	0	0	3,792	1,817
Lightning Creek	0	0	0	0	0	0	22	18	248	203	0	0	270	221
Upper Belle Fourche	0	0	0	0	0	0	26,339	13,085	10,159	5,192	0	0	36,498	18,277
Middle North Platte Casper	0	0	0	0	0	0	148	122	61	50	0	0	209	172
Total	56	46	0	0	7,956	3,992	75,887	35,970	167,755	75,113	1,249	602	252,903	115,723

Table 4–50 Pronghorn Water Handling Disturbances by Sub-watershed — Alternative 2A

	Disturbance (acres)									
	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	186	285	2,280	3,488	2,466	3,773
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	1,362	1,777	5,861	7,649	7,741	10,102	14,964	19,528
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	12	20	6	10	18	30
Crazy Woman Creek	0	0	0	0	0	0	2,922	4,471	2,922	4,471
Clear Creek	0	0	0	0	556	851	2,870	4,391	3,426	5,242
Middle Powder	182	244	46	62	0	0	655	878	883	1,183
Little Powder	0	0	18	24	846	1,134	1,128	1,512	1,992	2,669
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	77	85	1,567	1,739	1,644	1,825
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	242	269	291	323	533	592
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	4,225	4394	1,651	1,717	5,876	6,111
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	182	244	1,426	1,863	12,005	14,685	21,111	28,631	34,724	45,423

White-tailed Deer

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–51 and Table 4–52 present estimates or disturbance for range by surface owner and sub-watershed, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–53). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–51 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	609	246	0	0	116	59	1,837	669	13,516	5,340	16,078	6,314
Winter Yearlong	39	32	0	0	0	0	0	0	0	32	78	64
Total	648	278	0	0	116	59	1,837	669	13,516	5,372	16,156	6,378

Table 4–52 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Sub-watershed — Alternative 2A

	Disturbance (acres)					
	Winter Range		Winter Yearlong Range		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	0	0	6,620	3,264	6,620	3,264
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	0	0	4,613	2,345	4,613	2,345
South Fork Powder	0	0	6	5	6	5
Salt Creek	0	0	0	0	0	0
Crazy Woman Creek	0	0	1,140	554	1,140	554
Clear Creek	0	0	5,350	2,750	5,350	2,750
Middle Powder River	39	32	126	65	165	97
Little Powder River	0	0	1,871	1,195	1,871	1,195
Little Missouri	0	0	0	0	0	0
Antelope Creek	0	0	252	100	252	100
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	180	115	180	115
Middle North Platte Casper	0	0	0	0	0	0
Total	39	32	20,201	10,428	20,240	10,460

Table 4–53 White-tailed Deer Water Handling Disturbances by Sub-watershed — Alternative 2A

	Disturbance (acres)			
	Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0
Upper Tongue River	863	1,320	863	1,320
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder River	806	1,052	806	1,052
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	156	239	156	239
Clear Creek	881	1,348	881	1,348
Middle Powder	18	24	18	24
Little Powder	72	96	72	96
Little Missouri	0	0	0	0
Antelope	9	10	9	10
Dry Fork Cheyenne	0	0	0	0
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	19	20	19	20
Middle N Platte Casper	0	0	0	0
Total	2,824	4,109	2,824	4,109

Mule Deer

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–54 and Table 4–55 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–56). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–54 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM BFO		BLM CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6,321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–55 Direct Short-term and Long-term Effects to Mule Deer Ranges by Sub-watershed — Alternative 2A

	Mule Deer Ranges					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	14,910	5,329	1,562	1,518	16,472	6,847
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	49,274	17,579	29,796	11,268	79,069	28,847
South Fork Powder	0	0	6	5	6	5
Salt Creek	957	329	144	50	1,101	379
Crazy Woman Creek	11,869	4,183	4,815	1,850	16,685	6,034
Clear Creek	14,817	5,245	3,201	2,025	18,018	7,270
Middle Powder River	3,972	1,469	1,404	518	5,376	1,986
Little Powder River	3,095	1,096	13,362	5,253	16,457	6,349
Little Missouri	0	0	0	0	0	0
Antelope Creek	770	279	20,780	7,286	21,550	7,565
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	11,956	4,327	11,956	4,327
Middle North Platte Casper	0	0	0	0	0	0
Total	99,663	35,508	88,145	34,543	187,808	70,051

Table 4–56 Mule Deer Water Handling Disturbances by Sub-watershed — Alternative 2A

Sub-watershed	Yearlong		Winter Yearlong		Total	
	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0
Upper Tongue River	863	1,320	2,589	3,961	3,452	5,282
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder River	806	1,052	11,496	15,002	12,302	16,054
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	51	31	51
Crazy Woman Creek	156	239	0	0	156	239
Clear Creek	881	1,348	0	0	881	1,348
Middle Powder	18	24	688	922	706	946
Little Powder	72	96	0	0	72	96
Little Missouri	0	0	0	0	0	0
Antelope	9	10	0	0	9	10
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	19	20	0	0	19	20
Middle N Platte Casper	0	0	0	0	0	0
Total	2,824	4,109	14,804	19,936	17,628	24,046

Elk

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–57, Table 4–58, Table 4–59, and Table 4–60 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance acres from water handling methods were available for range disturbance by sub-watershed (Table 4–61). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–57 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 2A

Range	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6,321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–58 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 2A

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	14,910	5,329	1,562	1,518	16,472	6,847
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	49,274	17,579	29,796	11,268	79,069	28,847
South Fork Powder	0	0	6	5	6	5
Salt Creek	957	329	144	50	1,101	379
Crazy Woman Creek	11,869	4,183	4,815	1,850	16,685	6,034
Clear Creek	14,817	5,245	3,201	2,025	18,018	7,270
Middle Powder River	3,972	1,469	1,404	518	5,376	1,986
Little Powder River	3,095	1,096	13,362	5,253	16,457	6,349
Little Missouri	0	0	0	0	0	0
Antelope Creek	770	279	20,780	7,286	21,550	7,565
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	11,956	4,327	11,956	4,327
Middle North Platte Casper	0	0	0	0	0	0
Total	99,663	35,508	88,145	34,543	187,808	70,051

Table 4–59 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 2A

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	3,540	1,276	0	0	0	0	675	245	3,870	2,916	8,085	2,916
Parturition	1,416	514	0	0	0	0	342	125	1,534	1,194	3,292	1,194
Winter Yearlong	1,948	702	0	0	0	0	446	162	2,125	1,634	4,519	1,634
Crucial Winter Range	467	170	0	0	0	0	215	78	1,308	724	1,990	724

Table 4–60 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 2A

	Elk Ranges							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder	10,965	5,798	4,452	2,353	6,123	3,237	2,684	1,418
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	10,965	5,798	4,452	2,353	6,123	3,237	2,684	1,418

Table 4–61 Elk (Fortification Creek only) Water Handling Disturbances by Sub-watershed – Alternative 2A

	Disturbance (acres)							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	22,080	2,881	888	1,159	1,228	1,603	532	694
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder	0	0	0	0	0	0	0	0
Little Powder	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle N Platte Casper	0	0	0	0	0	0	0	0
Total	22,080	2,881	888	1,159	1,228	1,603	532	694

Moose

Under Alternative 2A, proposed well pads, compressors, and other facilities would not affect any of the five moose ranges that occur in the Project Area.

Raptors

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water-handling methods would not likely affect raptors directly, but may affect habitats that support prey species. Potential adverse effects of water-handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium-sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scales relevant to predatory species, including raptors. For more information regarding potential effects to habitats, refer to the vegetation section of this chapter.

Upland Game Birds

Sage Grouse and Plains Sharp-Tailed Grouse

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water-handling methods would not likely affect grouse species directly, but would affect habitats that support these species. Potential adverse effects of water-handling facilities may include localized destruction of nesting, feeding, and brood rearing habitats. Estimates of disturbances to vegetation types are presented in the vegetation section of this chapter.

Waterfowl

Direct and Indirect Effects

Under Alternative 2A, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2A and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water-handling methods between Alternatives 2A and 1 differ most substantially in the number of acres disturbed from construction of infiltration impoundments. Alternative 2A would potentially disturb 32,253 acres, more than twice the acreage proposed for infiltration impoundments in Alternative 1. This shift in emphasis to infiltration impoundments may create new feeding, resting, and nesting habitats. These areas are not expected to be important to local waterfowl because of the availability of existing habitats.

Alternative 2B

Alternative 2B is similar to Alternative 1 in the type and magnitude of disturbance associated with the Project. However, Alternative 2B does differ in the proportions assigned to the various water handling methods. Under this alternative, as compared to Alternative 1, there would be an increased emphasis on the use of infiltration, containment reservoirs, and LAD; and a decreased emphasis on the use of surface discharge. These differences in water handling would result in variations of habitat disturbance and would not be expected to have unique or different effect types from those presented under Alternative 1. For a complete assessment of potential effect types, refer to Alternative 1 of this chapter.

Terrestrial Species

Big Game

Pronghorn

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–62 and Table 4–63 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–64). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–62 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	39	32	0	0	17	14	14	46
Crucial Winter Yearlong	0	0	0	0	0	0	0	0	0	0	0	0
Winter	1,532	582	0	0	0	0	621	261	4,860	2,205	13,919	3,048
Winter Yearlong	4,359	1,620	17	14	1,135	491	2,693	1,122	57,572	22,609	143,025	25,856
Yearlong	13,330	5,099	39	32	9,199	3,734	12,843	4,797	114,137	43,270	325,388	56,932
Spring, Summer, Fall	102	41	17	14	0	0	11	9	969	387	2,309	451
Total	19,323	7,342	73	60	10,373	4,257	16,168	6,189	177,555	68,485	484,655	86,333

Table 4–63 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed — Alternative 2B

	Pronghorn Ranges													
	Severe Winter		Crucial Winter		Winter		Winter Yearlong		Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	1,396	646	16,047	7,591	0	0	17,444	8,238
Middle Fork Powder	0	0	0	0	0	0	44	36	6	5	28	23	78	64
North Fork Powder	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Upper Powder	0	0	0	0	7,115	3,578	32,419	16,113	43,248	21,333	6	5	82,787	41,028
South Fork Powder	0	0	0	0	0	0	0	0	17	14	0	0	17	14
Salt Creek	0	0	0	0	0	0	423	170	220	114	28	23	671	307
Crazy Woman Creek	0	0	0	0	0	0	6	5	20,126	9,463	0	0	20,132	9,468
Clear Creek	0	0	0	0	0	0	3,175	1,579	16,408	8,158	0	0	19,583	9,737
Middle Powder River	0	0	0	0	309	165	0	0	4,867	2,398	1,235	599	6,411	3,162
Little Powder River	0	0	0	0	1,168	885	10,972	5,471	15,960	8,261	0	0	28,100	14,617
Little Missouri	0	0	0	0	0	0	17	14	435	356	0	0	452	370
Antelope Creek	28	23	0	0	0	0	2,170	822	43,320	16,495	0	0	45,518	17,340
Dry Fork Cheyenne	28	23	0	0	0	0	50	41	193	158	0	0	271	222
Upper Cheyenne	0	0	0	0	0	0	1,629	771	2,197	1,080	0	0	3,826	1,851
Lightning Creek	0	0	0	0	0	0	22	18	248	203	0	0	270	221
Upper Belle Fourche	0	0	0	0	0	0	26,064	12,810	10,052	5,085	0	0	36,116	17,895
Middle North Platte Casper	0	0	0	0	0	0	148	122	61	50	0	0	209	172
Total	56	46	0	0	8,591	4,627	78,535	38,618	173,411	80,769	1,297	650	261,890	124,710

Table 4–64 Pronghorn Water Handling Disturbances by Sub-watershed – Alternative 2B

	Disturbance (acres)									
	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	186	224	2,280	2,747	2,466	2,972
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	1,362	1,512	5,861	6,506	7,741	8,593	14,964	16,610
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	12	20	6	10	18	30
Crazy Woman Creek	0	0	0	0	0	0	2,922	3,609	2,922	3,609
Clear Creek	0	0	0	0	556	687	2,870	3,544	3,426	4,231
Middle Powder	182	197	46	50	0	0	655	707	883	954
Little Powder	0	0	18	19	846	884	1,128	1,179	1,992	2,082
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	77	75	1,567	1,536	1,644	1,611
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	242	237	291	285	533	522
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	4,225	4,119	1,651	1,610	5,876	5,729
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	182	197	1,426	1,580	12,005	12,752	21,111	23,820	34,724	38,349

White-tailed Deer

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–65 and Table 4–66 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–67). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–65 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	609	246	0	0	116	59	1,837	669	13,516	5,340	16,078	6,314
Winter Yearlong	39	32	0	0	0	0	0	0	0	32	78	64
Total	648	278	0	0	116	59	1,837	669	13,516	5,372	16,156	6,378

Table 4–66 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Sub-watershed — Alternative 2B

	Disturbance (acres)					
	Yearlong		Spring, Summer, Fall		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0
Upper Tongue River	16,047	7,591	0	0	17,444	8,238
Middle Fork Powder	6	5	28	23	78	64
North Fork Powder	6	5	0	0	6	5
Upper Powder	43,248	21,333	6	5	82,787	41,028
South Fork Powder	17	14	0	0	17	14
Salt Creek	220	114	28	23	671	307
Crazy Woman Creek	20,126	9,463	0	0	20,132	9,468
Clear Creek	16,408	8,158	0	0	19,583	9,737
Middle Powder River	4,867	2,398	1,235	599	6,411	3,162
Little Powder River	15,960	8,261	0	0	28,100	14,617
Little Missouri	435	356	0	0	452	370
Antelope Creek	43,320	16,495	0	0	45,518	17,340
Dry Fork Cheyenne	193	158	0	0	271	222
Upper Cheyenne	2,197	1,080	0	0	3,826	1,851
Lightning Creek	248	203	0	0	270	221
Upper Belle Fourche	10,052	5,085	0	0	36,116	17,895
Middle North Platte Casper	61	50	0	0	209	172
Total	173,411	80,769	1,297	650	261,890	124,710

Table 4–67 White-tailed Deer Water Handling Disturbances by Sub-watershed — Alternative 2B

	Yearlong		Total	
	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0
Upper Tongue River	863	1,040	863	1,040
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder River	806	895	806	895
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	156	193	156	193
Clear Creek	881	1,088	881	1,088
Middle Powder	18	19	18	19
Little Powder	72	75	72	75
Little Missouri	0	0	0	0
Antelope	9	9	9	9
Dry Fork Cheyenne	0	0	0	0
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	19	19	19	19
Middle N Platte Casper	0	0	0	0
Total	2,824	3,337	2,824	3,337

Mule Deer

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–68 and Table 4–69 present estimates of disturbance for ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–70). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–68 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	17,679	6,321	0	0	52	18	8,230	2,905	73,676	26,244	99,637	35,488
Yearlong	8,107	2,901	0	0	2,218	795	4,690	0	68,613	24,848	83,628	30,206
Total	25,786	9,222	0	0	2,270	813	12,920	2,905	142,289	51,092	183,265	65,694

Table 4–69 Disturbance to Mule Deer Ranges by Sub-watershed — Alternative 2B

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	18,029	8,448	1,282	1,238	19,311	9,686
Middle Fork Powder	0	0	17	14	17	14
North Fork Powder	0	0	0	0	0	0
Upper Powder	62,034	30,340	29,638	11,111	91,673	41,451
South Fork Powder	0	0	6	5	6	5
Salt Creek	1,008	380	144	50	1,152	430
Crazy Woman Creek	11,869	4,183	4,769	1,804	16,639	5,988
Clear Creek	14,817	5,245	2,941	1,765	17,758	7,010
Middle Powder River	4,715	2,212	1,399	513	6,114	2,725
Little Powder River	3,095	1,096	13,341	5,231	16,435	6,328
Little Missouri	0	0	0	0	0	0
Antelope Creek	770	279	20,779	7,285	21,549	7,563
Dry Fork Cheyenne	0	0	11	9	11	9
Upper Cheyenne	0	0	1,076	406	1,076	406
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	0	0	11,954	4,326	11,954	4,326
Middle North Platte Casper	0	0	0	0	0	0
Total	116,337	52,182	87,373	33,771	203,711	85,953

Table 4–70 Mule Deer Water Handling Disturbances by Sub-watershed – Alternative 2B

	Disturbance (acres)					
	Yearlong		Winter Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0
Upper Tongue River	863	1,040	2,589	3,120	3,452	4,160
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder River	806	895	11,496	12,761	12,302	13,655
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	51	31	51
Crazy Woman Creek	156	193	0	0	156	193
Clear Creek	881	1,088	0	0	881	1,088
Middle Powder	18	19	688	743	706	762
Little Powder	72	75	0	0	72	75
Little Missouri	0	0	0	0	0	0
Antelope	9	9	0	0	9	9
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	19	19	0	0	19	19
Middle N Platte Casper	0	0	0	0	0	0
Total	2,824	3,337	14,804	16,674	17,628	20,012

Elk

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. Table 4–71, Table 4–72, Table 4–73, and Table 4–74 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–75). For an assessment of potential effects, refer to text under Alternative 1.

Table 4–71 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	50	41	28	23	39	32	6	5	132	108	254	208
Crucial Winter Yearlong	11	9	0	0	0	0	17	14	17	14	44	36
Crucial Winter	11	9	0	0	0	0	11	9	33	27	55	45
Spring, Summer, Fall	6	5	0	0	0	0	0	0	11	9	17	14
Winter	0	0	0	0	0	0	0	0	17	14	17	14
Winter Yearlong	11	9	0	0	11	9	0	0	28	23	50	41
Total	89	73	28	23	50	41	33	27	237	194	599	357

Table 4–72 Disturbance to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 2B

	Disturbance (acres)													
	Crucial Winter		Crucial Winter Yearlong		Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	5	0	0	0	0	0	0	0	0	0	0	6	5
Middle Fork Powder	0	0	44	36	11	9	0	0	0	0	0	0	55	45
North Fork Powder	0	0	0	0	0	0	0	0	0	0	6	5	6	5
Upper Powder	0	0	0	0	0	0	0	0	0	0	39	32	39	32
South Fork Powder	0	0	0	0	0	0	0	0	0	0	6	5	6	5
Salt Creek	0	0	0	0	0	0	0	0	0	0	28	23	28	23
Crazy Woman Creek	0	0	0	0	0	0	6	5	0	0	0	0	6	5
Clear Creek	0	0	0	0	6	5	11	9	0	0	0	0	17	14
Middle Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0	6	5	50	41	55	45
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0	17	14	77	63	94	77
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0	0	0	11	9	11	9
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6	5	44	36	17	14	17	14	22	18	215	176	319	261

Table 4–73 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 2B

	Disturbance (acres)											
	BLM											
	Buffalo FO		Casper FO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	3,540	1,276	0	0	0	0	675	245	3,870	1,395	8,085	2,916
Parturition	1,416	514	0	0	0	0	342	125	1,534	555	3,292	1,194
Winter Yearlong	1,948	702	0	0	0	0	446	162	2,125	770	4,519	1,634
Crucial Winter Range	467	170	0	0	0	0	215	78	1,308	476	1,990	724

Table 4–74 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 2B

	Disturbance (acres)							
	Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder	10,535	5,368	4,279	2,180	5,883	2,997	2,581	1,315
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	10,535	5,368	4,279	2,180	5,883	2,997	2,581	1,315

Table 4–75 Elk (Fortification Creek only) Water Handling Disturbances by Sub-watershed — Alternative 2B

	Disturbance (acres)							
	Yearlong		Parturition		Winter Yearlong		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	2,208	2,451	888	986	1,228	1,363	532	591
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder	0	0	0	0	0	0	0	0
Little Powder	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle N Platte - Casper	0	0	0	0	0	0	0	0
Total	2,208	2,451	888	986	1,228	1,363	532	591

Moose

Under Alternative 2B, proposed well pads, compressors, and other facilities would not impact any of the five moose ranges that occur in the Project Area.

Raptors

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water handling methods would not likely affect raptors directly, but may affect habitats that support prey species. Potential adverse effects of water handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium-sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scales relevant to predatory species, including raptors. For more information regarding potential effects to habitats, refer to the vegetation section of this chapter.

Upland Game Birds

Sage Grouse and Plains Sharp-tailed Grouse

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water Handling

Water handling methods would not likely affect grouse species directly, but would affect habitats that support these species. Potential adverse effects of water handling facilities may include localized destruction of nesting, feeding, and brood-rearing habitats. Estimates of disturbances to vegetation types are presented in the vegetation section of this chapter.

Waterfowl

Direct and Indirect Effects

Under Alternative 2B, the magnitude and type of effects would be similar to those presented under Alternative 1, with the exception of the contribution of disturbance associated with proposed water handling. Alternatives 2B and 1 differ only by the proportion of the various water handling methods and their associated disturbances. For an assessment of potential effects, refer to text under Alternative 1.

Water handling methods between Alternative 1 and 2B differ most substantially in the number of acres disturbed from construction of infiltration impoundments. Alternative 2B would potentially disturb 23,446 acres, nearly twice the acreage proposed for infiltration impoundments in Alternative 1. This shift in emphasis to infiltration impoundments may create new feeding, resting, and nesting habitats. These areas are not expected to be important to local waterfowl because of the availability of existing habitats, but they may be utilized.

Alternative 3

Alternative 3 differs from the other alternatives in that development is restricted to non-federal leases. Because Alternative 3 is restricted to non-federal minerals, there are fewer wells and related facilities and subsequently less disturbance. Effects associated with this alternative would be similar in type to those presented in Alternative 1, 2A, and 2B but would be reduced in total disturbance acreage.

For a complete assessment of potential effect types, refer to description of Alternative 1 section in this chapter.

Terrestrial Species

Big Game

Pronghorn

<u>Direct and Indirect Effects</u>

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–76 and Table 4–77 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–78).

Table 4–76 Direct Short-term and Long-term Effects to Pronghorn Ranges by Surface Owner — Alternative 3

	Surface Owner (acres)											
	BLM											
	Buffalo FO		Casper FO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Severe Winter	0	0	0	0	0	0	0	0	17	14	17	14
Crucial Winter Yearlong	0	0	0	0	0	0	0	0	0	0	0	0
Winter	0	0	0	0	0	0	621	260	1,970	1,164	2,591	1,424
Winter Yearlong	0	0	0	0	330	117	2,473	1,045	28,200	12,227	31,003	13,389
Yearlong	28	10	0	0	1,632	572	12,308	4,608	53,730	21,848	67,698	27,038
Spring, Summer, Fall	0	0	0	0	0	0	11	9	323	157	334	166
Total	28	10	0	0	1,962	689	15,413	5,922	84,240	35,410	101,643	42,031

Table 4–77 Direct Short-term and Long-term Effects to Pronghorn Ranges by Sub-watershed — Alternative 3

Sub-watershed	Severe Winter Short-term	Severe Winter Long-term	Crucial Winter Yearlong Short-term	Crucial Winter Yearlong Long-term	Winter Short-term	Winter Long-term	Winter Yearlong Short-term	Winter Yearlong Long-term	Yearlong Short-term	Yearlong Long-term	Spring, Summer, Fall Short-term	Spring, Summer, Fall Long-term	Total Short-term	Total Long-term
	Disturbance (acres)													
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	126	152	1937	2334	2063	2486	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	329	215	1512	990	2042	1338	3883	2543	0	0	329	215
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	7	6	5	5	12	11	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	936	674	936	674	0	0	0	0
Clear Creek	0	0	0	0	332	388	1884	2204	2216	2593	0	0	0	0
Middle Powder River	20	16	8	7	0	0	165	135	193	158	20	16	8	7
Little Powder River	0	0	12	10	379	311	566	464	957	785	0	0	12	10
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	39	36	564	516	603	552	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	121	111	139	127	260	238	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	2240	2330	1115	1160	3355	3489	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	20	16	349	232	4756	4324	9353	8957	14478	13529	20	16	349	232

Table 4–78 Pronghorn Water Handling Disturbances by Sub-watershed — Alternative 3

	Disturbance (acres)									
	Spring, Summer, Fall		Winter		Winter Yearlong		Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	126	152	1,937	2,334	2,063	2,486
Middle Fork Powder	0	0	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0	0	0
Upper Powder River	0	0	329	215	1,512	990	2,042	1,338	3,883	2,543
South Fork Powder	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	7	6	5	5	12	11
Crazy Woman Creek	0	0	0	0	0	0	936	674	936	674
Clear Creek	0	0	0	0	332	388	1,884	2,204	2,216	2,593
Middle Powder	20	16	8	7	0	0	165	135	193	158
Little Powder	0	0	12	10	379	311	566	464	957	785
Little Missouri	0	0	0	0	0	0	0	0	0	0
Antelope	0	0	0	0	39	36	564	516	603	552
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	121	111	139	127	260	238
Lightning Creek	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	2,240	2,330	1,115	1,160	3,355	3,489
Middle N Platte Casper	0	0	0	0	0	0	0	0	0	0
Total	20	16	349	232	4,756	4,324	9,353	8,957	14,478	13,529

White-tailed Deer

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–79 and Table 4–80 present ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–81).

Table 4–79 Direct Short-term and Long-term Effects to White-tailed Deer Ranges by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Year Long	66	54	0	0	354	143	4,161	1,486	25,586	9,568	30,166	11,251
Winter Year Long	39	32	0	0	0	0	0	2,662	26,835	9,564	34,343	12,258
Total	105	86	0	0	354	143	4,161	4,148	52,421	19,132	64,509	23,509

Table 4–80 Direct Short-term and Long-term Effects To White-tailed Deer Ranges by Sub-watershed — Alternative 3

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	0	0	6,017	2,829	6,017	2,829
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	0	0	2,568	1143	2,568	11,435
South Fork Powder River	0	0	6	5	6	05
Salt Creek	0	0	0	0	0	0
Crazy Woman Creek	0	0	723	298	723	298
Clear Creek	0	0	4,545	2,213	4,545	2,213
Middle Powder River	22	18	43	20	65	38
Little Powder River	0	0	1,046	604	1,046	604
Little Missouri River	0	0	0	0	0	0
Antelope Creek	0	0	106	40	106	40
Dry Fork Cheyenne River	0	0	6	5	6	5
Upper Cheyenne River	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	132	80	132	80
Middle North Platte Casper	0	0	0	0	0	0
Total	22	18	15,224	7,262	15,246	7,280

Table 4–81 White-tailed Deer Water Handling Disturbances by Sub-watershed — Alternative 3

	Disturbance (acres)			
	Year Long		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn River	0	0	0	0
Upper Tongue River	813	980	813	980
Middle Fork Powder	0	0	0	0
North Fork Powder	0	0	0	0
Upper Powder	489	320	489	320
South Fork Powder	0	0	0	0
Salt Creek	0	0	0	0
Crazy Woman Creek	104	75	104	75
Clear Creek	810	948	810	948
Middle Powder River	8	7	8	7
Little Powder River	49	40	49	40
Little Missouri	0	0	0	0
Antelope Creek	4	4	4	4
Dry Fork Cheyenne	0	4	0	4
Upper Cheyenne	0	0	0	0
Lightning Creek	0	0	0	0
Upper Belle Fourche	16	17	16	17
Middle North Platte Casper	0	0	0	0
Total	2,293	2,390	2,293	2,390

Mule Deer

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–82 and Table 4–83 present estimates of disturbance to ranges by surface owner and sub-watershed. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–84).

Table 4–82 Direct Short-term and Long-term Effects to Mule Deer Ranges by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Winter Yearlong	0	0	0	0	0	0	8,051	2,842	32,241	9,564	40,292	12,406
Yearlong	66	54	0	0	354	143	4,557	0	26,590	115,173	31,567	116,987
Total	66	54	0	0	354	143	12,608	2,842	58,831	124,737	71,859	129,393

Table 4–83 Direct Short-term and Long-term Effects to Mule Deer Ranges by Sub-watershed — Alternative 3

	Disturbance (acres)					
	Winter Yearlong		Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	17	14	17	14
Upper Tongue River	4,617	3,641	5,222	2,524	9,839	6,166
Middle Fork Powder River	0	0	17	14	17	14
North Fork Powder River	0	0	0	0	0	0
Upper Powder River	9,716	8,308	3,924	1,624	13,640	9,932
South Fork Powder River	0	0	6	5	6	5
Salt Creek	115	55	0	0	115	55
Crazy Woman Creek	660	225	870	344	1,530	570
Clear Creek	1,239	421	4,182	2,110	5,422	2,531
Middle Powder River	719	626	43	20	762	646
Little Powder River	185	76	1,046	604	1,231	680
Little Missouri River	0	0	0	0	0	0
Antelope Creek	0	0	289	104	289	104
Dry Fork Cheyenne River	0	0	6	5	6	5
Upper Cheyenne River	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche River	0	0	1,004	425	1,004	425
Middle North Platte Casper	0	0	0	0	0	0
Total	17,252	13,352	16,625	7,790	33,877	21,142

Table 4–84 Mule Deer Water Handling Disturbances by Sub-watershed — Alternative 3

	Disturbance (acres)					
	Yearlong		Winter Yearlong		Total	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn River	0	0	0	0	0	0
Upper Tongue River	813	980	2,589	3,120	3,402	4,099
Middle Fork Powder	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0
Upper Powder	489	320	11,496	7,530	11,985	7,850
South Fork Powder	0	0	0	0	0	0
Salt Creek	0	0	31	28	31	28
Crazy Woman Creek	104	75	0	0	104	75
Clear Creek	810	948	0	0	810	948
Middle Powder River	8	7	688	564	696	571
Little Powder River	49	40	0	0	49	40
Little Missouri	0	0	0	0	0	0
Antelope Creek	4	4	0	0	4	4
Dry Fork Cheyenne	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0
Upper Belle Fourche	16	17	0	0	16	17
Middle North Platte Casper	0	0	0	0	0	0
Total	2,293	2,390	14,804	11,242	17,097	13,632

Elk

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. Table 4–85, Table 4–86, Table 4–87, and Table 4–88 present estimates of disturbance to ranges by surface owner and sub-watershed, respectively. Estimates of disturbance from water handling methods were available for range disturbance by sub-watershed (Table 4–89).

Table 4–85 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Yearlong	0	0	0	0	0	0	675	245	544	195	1,219	440
Parturition	0	0	0	0	0	0	342	125	61	22	403	147
Winter Yearlong	0	0	0	0	0	0	446	162	175	63	621	225
Crucial Winter Range	0	0	0	0	0	0	215	78	63	30	278	108

Table 4–86 Direct Short-term and Long-term Effects to Elk Ranges (Fortification Creek only) by Sub-watershed — Alternative 3

	Disturbance (acres)							
	Year Long		Parturition		Winter Year Long		Crucial Winter Range	
Sub-watershed	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	9,530	4,363	1,567	1,567	5,324	2,438	2,338	1,072
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	9,530	4,363	1,567	1,567	5,324	2,438	2,338	1,072

Table 4–87 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Surface Owner — Alternative 3

	Disturbance (acres)											
	BLM											
	BFO		CFO		FS		State		Private		Total	
Range	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Year Long	50	41	28	0	0	0	88	33	244	111	410	185
Critical Winter Year Long	11	9	0	0	0	0	0	0	88	33	99	42
Critical Winter	11	9	0	0	0	0	11	9	6	5	28	23
Spring/Summer/Fall	6	5	0	0	0	0	0	0	6	5	12	10
Winter	0	0	0	0	0	0	0	0	11	9	11	9
Winter Year Long	11	9	0	0	0	0	0	0	0	0	11	9
TOTAL	89	73	28	0	0	0	99	42	354	162	571	278

Table 4–88 Direct Short-term and Long-term Effects to Elk Ranges (excluding Fortification Creek) by Sub-watershed — Alternative 3

	Disturbance (acres)													
	Crucial Winter		Yearlong		Crucial Winter Yearlong		Spring, Summer, Fall		Winter		Winter Yearlong		Total	
Sub-watershed	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	5	0	0	0	0	0	0	0	0	0	0	6	5
Middle Fork Powder	0	0	0	0	6	5	0	0	0	0	0	0	6	5
North Fork Powder	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder	11	9	775	288	83	28	0	0	0	0	338	122	432	159
South Fork Powder	283	103	6	5	0	0	0	0	0	0	0	0	283	103
Salt Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0	6	5	0	0	6	5
Clear Creek	0	0	0	0	0	0	6	5	6	5	0	0	12	10
Middle Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	17	14	0	0	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	11	9	0	0	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	300	117	808	315	89	33	6	5	12	10	338	122	745	287

Table 4–89 Elk (Fortification Creek only) Water-Handling Disturbances by Surface Owner — Alternative 3

	Year Long		Parturition		Winter Year Long		Crucial Winter Range	
Sub-watershed	No. of wells	H_2O Handling Disturbance Acres	No. of wells	H_2O Handling Disturbance. Acres	No. of wells	H_2O Handling Disturbance acres	No. of wells	H_2O Handling Disturbance Acres
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Middle Fork Powder	0	0	0	0	0	0	0	0
North Fork Powder	0	0	0	0	0	0	0	0
Upper Powder River	2,208	1,446	888	582	1,228	804	532	348
South Fork Powder	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0	0
Little Missouri	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne	0	0	0	0	0	0	0	0
Upper Cheyenne	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche	0	0	0	0	0	0	0	0
Middle North Platte Casper	0	0	0	0	0	0	0	0
Total	2,208	1,446	888	582	1,228	804	532	348

Moose

Direct and Indirect Effects

Under Alternative 3, no moose habitats would be directly or indirectly affected.

Raptors

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. The following tables present estimates of disturbance to range by surface owner and sub-watershed under this alternative. These estimates include disturbances associated with water handling methods.

Water Handling

Water handling methods would not likely affect raptors directly, but may affect habitats that support prey species. Potential adverse effects of water handling facilities may include localized destruction of prey habitats and possible changes in population numbers of locally occurring prey species (e.g., small- and medium- sized mammals). Any potential effects to local prey populations would be highly localized and not expected to affect prey populations at scales relevant to predatory species, including raptors. For more information regarding potential effects to habitats, refer to the vegetation section of this chapter.

Upland Game Birds

Sage Grouse and Plains Sharp-tailed Grouse

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. The following tables present estimates of disturbance to range by surface owner and sub-watershed under this alternative. These estimates include disturbances associated with water handling methods.

Water Handling

Water handling methods would not likely affect grouse species directly, but would affect habitats that support these species. Potential adverse effects of water handling facilities may include localized destruction of nesting, feeding, and brood rearing habitats. Estimates of disturbances to vegetation types are presented in the vegetation section of this chapter.

Waterfowl

Direct and Indirect Effects

Under Alternative 3, the effect types would be similar and the estimated magnitude of effects would be less than those presented under the other alternatives. For an assessment of potential effects, refer to text under Alternative 1. The following tables present estimates of disturbance to range by surface owner and sub-watershed under this alternative. These estimates include disturbances associated with water handling methods.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects to big game species in the Project Area. Cumulative short- and long-term disturbance to big game species by alternative and sub-watershed are presented for each big game species. Included in this cumulative analysis are the direct effects of oil and gas (conventional and CBM) development. The Alternative 3 data do not include potential new federal wells that would be developed in response to drainage situations caused by production on adjacent state or fee minerals. Additional oil and gas development (conventional and CBM) may occur at a later date beyond the level of development considered in this analysis. Other activities contributing to cumulative effects to wildlife in the Project Area include: coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing development.

On-going coal mining activities disturb surface lands at a rate of approximately 2,000 acres per year, with 1,850 acres successfully reclaimed on annual basis. At present, approximately 54,000 acres have been disturbed by coal mining, while 20,200 acres have been successfully reclaimed. An unknown portion of disturbed coal mining area is currently undergoing reclamation, but has not yet met success standards. A similar level of both new disturbance and reclamation success is expected in the near future.

Uranium mining has resulted in the disturbance of approximately 4,400 acres, while sand, gravel, and scoria mining has resulted in the disturbance of approximately 1,200 acres. Agriculture has resulted in impacts to approximately 113,643 acres of lands formally occupied by native vegetation that may be suitable to wildlife. Urban development has resulted in the loss of approximately 4,362 acres of native vegetation that may be suitable wildlife habitat. A minor amount of new rural and urban development is expected in the foreseeable future but no estimate of the amount or types of vegetation disturbance has been made. Cumulative impacts to vegetation from roads, railroads, and rural development have not been estimated.

The total acreage affected by CBM development would not be disturbed simultaneously, because Project development would occur over the life of the Project. Some of the disturbed acreage would be reclaimed or would be in the process of being reclaimed when new disturbances are initiated. CBM development is expected to occur at a rate faster than abandonment and reclamation of wells. In the near future, the amount of disturbed habitats is likely to increase, although the anticipated life of CBM wells (12-20 years) indicates that reclamation would eventually overtake new well development, resulting in a net decrease in disturbed vegetation for the long-term.

Cumulative effects would also occur to vegetation resources as a result of indirect impacts. One impact is the potential import and spread of noxious weeds around Project facilities. Noxious weeds have the ability to displace native vegetation and hinder reclamation efforts. If weed mitigation and preventative procedures are applied to all construction and reclamation practices, the impact of noxious weeds would be minimized.

In areas reclaimed after CBM development, the reclaimed areas often differ substantially from undisturbed areas in terms of vegetation cover. Reclaimed areas may not serve ecosystem functions presently served by undisturbed vegetation communities and habitats, particularly in the short-term, when species composition, shrub cover, and other environmental factors are likely to be different. Establishment of noxious weeds and alternation of vegetation along drainages and reclaimed areas has the potential to alter wildlife habitat composition and distribution. As a result, shifts in habitat composition or distribution may affect wildlife species within the Project Area.

Pronghorn, White-tailed Deer, Mule Deer, and Elk

The following tables present the cumulative percentage of total big game range disturbance in the sub-watersheds for each alternative for pronghorn (Table 4–90), white-tailed deer (

Table 4–91), mule deer (Table 4–92), and elk (Table 4–93).

Table 4–90 Cumulative Habitat Loss in Sub-watersheds by Alternative for Pronghorn

	Alternative							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.02
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.07	0.04	0.08	0.04	0.07	0.04	0.03	0.02
South Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt Creek	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Crazy Woman Creek	0.04	0.02	0.04	0.02	0.04	0.02	0.01	0.01
Clear Creek	0.04	0.02	0.05	0.03	0.04	0.02	0.03	0.02
Middle Powder River	0.05	0.04	0.05	0.05	0.05	0.05	0.03	0.03
Little Powder River	0.07	0.05	0.07	0.05	0.07	0.05	0.06	0.05
Little Missouri River	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Antelope Creek	0.09	0.04	0.09	0.04	0.09	0.04	0.04	0.03
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.03	0.02	0.04	0.02	0.03	0.02	0.02	0.02
Lightning Creek	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper Belle Fourche River	0.09	0.06	0.09	0.06	0.09	0.06	0.07	0.06
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.02

Table 4–91 Cumulative Habitat Loss in Sub-watersheds by Alternative for White-tailed Deer

	Alternative							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.04	0.02	0.04	0.01	0.04	0.01	0.03	0.01
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.08	0.05	0.09	0.03	0.09	0.03	0.06	0.03
South Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crazy Woman Creek	0.03	0.02	0.03	0.01	0.03	0.01	0.02	0.01
Clear Creek	0.05	0.03	0.05	0.02	0.05	0.02	0.04	0.02
Middle Powder River	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Little Powder River	0.03	0.02	0.03	0.01	0.03	0.01	0.02	0.01
Little Missouri River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Antelope Creek	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lightning Creek	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.00
Upper Belle Fourche River	0.04	0.03	0.04	0.01	0.04	0.01	0.03	0.01
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	0.04	0.01	0.04	0.01	0.03	0.01

Table 4–92 Cumulative Habitat Loss in Sub-watersheds by Alternative for Mule Deer

	Alternatives							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.03	0.02	0.03	0.02	0.03	0.02	0.02	0.02
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.07	0.03	0.06	0.03	0.07	0.04	0.02	0.02
South Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Salt Creek	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.00
Crazy Woman Creek	0.03	0.01	0.03	0.01	0.03	0.01	0.00	0.00
Clear Creek	0.04	0.02	0.04	0.02	0.04	0.02	0.01	0.01
Middle Powder River	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.03
Little Powder River	0.05	0.03	0.05	0.03	0.05	0.03	0.03	0.03
Little Missouri River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Antelope Creek	0.05	0.02	0.05	0.02	0.05	0.02	0.01	0.01
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01
Lightning Creek	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Upper Belle Fourche River	0.06	0.04	0.06	0.04	0.06	0.04	0.03	0.03
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	0.02	0.04	0.02	0.04	0.02	0.02	0.01

Table 4–93 Cumulative Habitat Loss in Sub-watersheds by Alternative for Elk (excluding Fortification Creek)

	Alternatives							
	1		2A		2B		3	
Sub-watershed	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)	Short-term (percent)	Long-term (percent)
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Tongue River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Middle Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Fork Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Powder River	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.03
South Fork Powder River	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02
Salt Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crazy Woman Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Clear Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Middle Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Little Powder River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Little Missouri River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Antelope Creek	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Cheyenne River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lightning Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Belle Fourche River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Middle North Casper River	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	0.04	0.04	0.04	0.04	0.04	0.12	0.06

Moose

Cumulative effects to the moose were not evaluated because none of the proposed alternatives directly affect moose habitat within the Project Area. Cumulative effects to existing moose habitats may occur as exploration and development of gas and mineral resources continue in the Powder River Basin. Indirect cumulative effects include the potential establishment of noxious weeds that may reduce the quantity and quality of existing moose habitats.

Raptors

Negative cumulative effects to raptors resulting from current, proposed and future activities such as gas and mineral exploration and development, agricultural activities, and urban development may include increased disturbance to nesting raptors, degradation and/or destruction of nesting habitats, increased raptor collisions with power lines and fences, increased electrocutions, and increased vehicular collisions with carrion-feeding raptors. As development brings additional power lines to the Project Area, the use of power poles as perches may be a positive effect to raptor species. This positive effect may lead to an increased hunting efficiency which, in turn, may result in higher fledging rates for nesting raptors.

Upland Game Birds

Implementation of each of the alternatives would contribute to cumulative effects to upland game birds that occur within the Project Area. These effects include increased human disturbance and physical degradation or destruction of breeding grounds (leks) and reproductive areas (nesting and brood-rearing areas).

Waterfowl

Potential negative cumulative effects may result following the implementation of each of the proposed alternatives. Negative effects would include degradation of existing nesting, feeding, and resting habitats resulting from potential increases or fluctuations in surface water levels. Positive effects would include the potential creation of suitable nesting, resting, or feeding habitats following surface containment features related to these proposed alternatives and/or future actions not addressed in this document.

Aquatic Species

For the purposes of this analysis, it is assumed that wells that discharge produced water on the surface and wells that discharge water to infiltration ponds may have potential effects on aquatic species. Water produced from wells and managed using other water handling-methods (containment, LAD, and injection) would not have effects on existing surface waters because none of the discharged water under these water handling methods would reach drainages in the subwatersheds. Therefore, these three water-handling methods will not be analyzed further.

Water handling methods were “modeled” and the models indicate that no discharged CBM water would reach mainstem rivers such as the Upper Tongue River, Powder River, Little Powder River, Cheyenne River, and Belle Fourche

River; however, for the purposes of this analysis, it is assumed that 20 percent of discharged water would reach mainstem rivers (Surface Water Quantity section). Projected annual outflows at sub-watershed boundaries are listed in Table 4–1, and annual flow characteristics at sub-watershed boundaries are listed in Table 3–5. A comparison of these two tables shows the projected increases in flow amounts by sub-watershed over the life of the Project.

The amount of water that may enter drainages below infiltration ponds due to rising water tables in shallow aquifers is unknown (Groundwater Flow section); however, if some of this water seeps into drainages, it could contribute to the surface water discharge effects discussed below.

With project adherence to NPDES permit requirements, discharges of CBM produced water to surface drainages would not likely result in violations of the Clean Water Act. The quality of produced water is not expected to noticeably affect aquatic life. NPDES permits specify water quality standards intended to protect designated uses, such as agriculture, livestock watering, and aquatic health. Therefore, water quality of receiving waters in the Powder River Basin should not be degraded to levels below aquatic life standards in tributaries and mainstems.

While containment reservoirs are expected to accumulate salts and heavy metals, they should not support fish species or macroinvertebrate populations; therefore, there should be no effect on aquatic species. Streams are not expected to accumulate salts and heavy metals to the point where aquatic species are affected. Table 3–2 shows CBM produced water quality in the PRB, including metals and salts.

Mitigation measures expected to eliminate or minimize potential effects to aquatic species are provided at the end of this chapter.

Alternative 1

Under Alternative 1, 62 percent of the proposed wells would discharge produced water on the surface and 23 percent would discharge produced water to infiltration reservoirs. Ten of eighteen sub-watersheds would receive produced water. Alternative 1 has the most proposed surface discharge of the four alternatives. Some direct/indirect effects may occur to aquatic species, assuming 20 percent of produced CBM water reaches some mainstem rivers.

Direct/Indirect Effects

Several effects of concern to aquatic species in the Project Area were considered in this analysis. Direct and indirect effects may include changes in timing and quantity of stream flows, increases and fluctuations in sedimentation, increases in concentrations of salts in streams, increasing concentrations of metals (e.g., barium, selenium), accidental spills of fuels or drilling fluids, and potential downstream trans-boundary water quality effects in Montana (Appendix B).

Timing and Quantity of Stream Flows

Stream flows are expected to increase to varying degrees in all ten sub-watersheds that would receive CBM produced water under Alternative 1 (Table

4-1). Increasing stream flows could have both positive and negative effects on aquatic species. The main positive effect would be to provide habitat to fish and macroinvertebrates in areas that are normally dry. This could provide opportunities for population growth. Increased flows may also benefit fisheries where containment and/or flow-through ponds are developed for fisheries. With proper water quality, these ponds could serve as sport fisheries or be used for breeding native species of concern.

Negative effects to fish could occur if streamflows are increased substantially, especially during spawning periods. Increased streamflows could make it difficult for certain species to migrate upstream to spawning and rearing areas, especially in reaches where manmade barriers exist (i.e. dams, water diversions). Increased flows in rearing areas may also make survival more difficult for young fish.

Groundwater depletions may impact current instream flows in isolated streams throughout the Project Area. These areas would likely be in shallow alluvium where coal seams are near the surface which could experience reductions in stream flows, but instream flows in the overall Project Area are not expected to be largely impacted by groundwater depletion because the affected aquifer is usually very deep.

Assuming that 20 percent of produced CBM from surface discharge would reach the sub-watersheds and comparing projected outflow numbers at sub-watershed boundaries (Table 4-1) to annual minimum flows (Table 3-5), the Upper Tongue River, Salt Creek, and Middle Powder River above Crazy Woman Creek would not see noticeable increases in stream flows during low flow periods. The other seven sub-watersheds may see noticeable increases in stream flows during low flow periods. These are the Upper Powder River, Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by the amount of surface water discharge under Alternative 1, especially during low flow periods.

Increases and Decreases in Sedimentation

Erosion rates in stream channels increase as instream flows increase, which may increase sedimentation in streams. For sub-watersheds in the Project Area, ten percent of soil loss would remain in the water flow at the point of exit from the sub-watershed (Blatt et al. 1972). Increased sedimentation can affect aquatic resources by filling interstitial (intergravel) spaces and pool habitats. This can reduce the availability of suitable spawning and rearing habitats. Aquatic macroinvertebrates are also highly dependent on interstitial spaces for different life stages, and sedimentation can cause large decreases in population numbers and change species compositions. This can be very detrimental to fisheries that are dependent on macroinvertebrates as primary food supplies and can change the abundance and diversity of fish populations.

Increased sedimentation may also reduce productivity of, or eliminate, rooted and un-rooted aquatic vegetation that many species of macroinvertebrates and fish depend on for food and habitat; this may also reduce populations of fish and macroinvertebrates. An increase of ten percent sediment load in these sub-watersheds (Sedimentation Section, Chapter 4) may have a minor impact on fish and macroinvertebrate species and their habitats.

Because produced CBM water is relatively low in sediments, receiving waters in streams and rivers may be more turbid, resulting in decreased turbidity and sedimentation. This could be detrimental to fish species that are dependent on turbid waters, and may allow for more aggressive exotic species invasion. However, naturally occurring turbid waters are generally well downstream of CBM discharge points and turbidity would likely be at near-natural levels when entering higher turbidity waters. These effects would be minimal and isolated.

The Upper Tongue River, Salt Creek, Middle Powder River, and Upper Cheyenne River would not see noticeable increases in stream flows or increased sedimentation and impacts to aquatic species would be minimal or non-existent. The other six sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Upper Powder River, Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation.

The proposed addition of over 17,000 miles of new roads within the Project Area would lead to additional sedimentation in drainages in all sub-watersheds within the Project Area. Roads allow for increased runoff that leads to increased sedimentation. Increased sedimentation resulting from roads would be most noticeable during storm events, including wind blowing dust off of roads which may enter drainage systems.

Increases and Decreases in Salt Concentrations

Increases in salt concentrations can alter the algae and macroinvertebrate composition of streams and, if sufficiently elevated, can alter the abundance and diversity of fish species. Projected CBM produced water has salinities that differ from the existing receiving waters in the ten sub-watersheds (surface water quality section in chapter 4). Salinity in receiving waters is predicted to increase slightly in the Upper Tongue River, Upper Powder River, Crazy Woman Creek, Clear Creek, Middle Powder River, and Antelope Creek sub-watersheds. Salinity is expected to decrease slightly in the Little Powder River, Upper Cheyenne River, and Upper Belle Fourche River sub-watersheds. Salinity in Salt Creek will remain unchanged. A substantial decrease in salinity (20 percent) in the Upper Belle Fourche River sub-watershed is predicted; this may affect fish and macroinvertebrate species, but may be beneficial to native species. The salinity in the remaining eight sub-watersheds would change by less than ten percent. Aquatic species may experience minor effects from the predicted changes in salinity, but population dynamics should not be affected.

A recent study by the Montana Fish, Wildlife, and Parks (Skaar 2001) described concerns relating to sodium bicarbonate toxicity to aquatic life in the Powder and Tongue Rivers. The study suggests that bicarbonate levels should be monitored for their potential effects on aquatic life, especially fish. Low, moderate, and high probability thresholds were modeled for each river to determine lethal limits to the fathead minnow; these limits can then be generally applied to many fish species. Limits were established at 530 mg/L to meet the low probability threshold, 1000 mg/L to meet the moderate threshold, and 1475 mg/L to meet the high threshold in the Tongue River near Miles City, Montana. They were established at 400 mg/L, 870 mg/L, and 1340 mg/L, respectively, for the Powder River near Locate, Montana. These established thresholds could be used to initiate a monitoring program for bicarbonate in all ten sub-watersheds that receive CBM produced water. Refer to Table 3-2 for measured bicarbonate levels in CBM produced waters within the Project Area. Fish and macroinvertebrates could be negatively impacted by elevated bicarbonate levels in the receiving sub-watersheds. Concentrations of bicarbonate are generally higher during low flow periods, and lower during high flow periods, resulting in greater accumulations and greater effects on aquatic life during low flow periods.

In addition to salts being added directly to surface drainages, CBM produced waters that do not reach drainages will evaporate and deposit salts in soils throughout the sub-watersheds. This accumulation of salts in the soils will continue as long as CBM produced water is discharged, and may be released into surface drainages and groundwater for years after the discharge of water ceases, further increasing salinity in surface drainages and potentially affecting fish and macroinvertebrates.

Increases in Metals

CBM produced water within the Project Area has been shown to contain low levels of metals such as selenium (Table 3-2). Effects of selenium on fish may range from physical malformations during embryonic development to sterility and death (Lemly and Smith 1987). Concentrations greater than 2 to 5 µg/L in water can cause reproductive failure or mortality in fish due to foodchain bioaccumulation (Lemly and Smith 1987). Selenium can be absorbed or ingested by organisms, can bind to particulate matter, or can remain free in solution. Most of it usually accumulates in the top layer of sediment and detritus. Selenium can then be cycled back into the biota and remain elevated for years after selenium input has stopped (Lemly and Smith 1987). Generally, flowing waters accumulate less selenium than do standing waters that have low flushing rates and recovery is much slower in shallow impoundments and wetlands than in fast-flowing rivers and streams (Lemly and Smith 1987).

Levels of selenium in CBM produced water in the Project Area are much lower than the specified level of concern. Water quality was analyzed in six sub-watersheds, and selenium was undetected in CBM produced water in the Antelope Creek and the Upper Cheyenne River sub-watersheds. Selenium was detected in CBM produced water in the Upper Powder River, Middle Powder River, Little Powder River, and Upper Belle Fourche River sub-watersheds. The highest mean selenium concentration within these sub-watersheds was 0.83 µg/L (Table 3–2), which is below hazardous levels to fish. Concentrations of selenium are generally higher during low flow periods, and lower during high flow periods, resulting in greater accumulations during low flow periods.

Although selenium concentrations were measured below hazardous limits, bioaccumulation of selenium may increase as more selenium is introduced into the ecosystem. Levels of selenium could reach dangerous levels for fish over the life of the Project. It is anticipated that containment ponds and reservoirs would have a much higher probability of achieving hazardous levels of selenium than do the stream and river systems within the ten sub-watersheds in the Project Area. Fish and macroinvertebrate species that may exist in ponds and reservoirs that receive CBM produced water may experience effects from selenium bioaccumulation. Fish and macroinvertebrate species in stream and river systems within the ten sub-watersheds may be impacted by increased selenium input.

Fuel and Drilling Fluid Spills

Fuel and drilling fluid spills can result in fish and macroinvertebrate kills and degradation of habitat. The severity and scope of a stream kill would depend upon the volume spilled, distance of the spill from surface water, and the chemical and toxicological properties of the spilled materials.

Increases or Decreases in Species Diversity

Changes in flow, sedimentation and turbidity, and water quality (including salinity and metals) could all potentially affect fish and macroinvertebrate species diversity, especially if these conditions remain changed for a long period. The longer the duration for CBM produced waters entering drainages, the greater the probability there would be of it affecting species diversity over larger portions of drainages.

Trans-boundary Water Quality Effects

The states of Wyoming and Montana have developed an Interim Water Quality Criteria MOC that states that water quality in streams and rivers entering Montana from Wyoming will not exceed set limits for toxicity due to CBM produced water being discharged in Wyoming. Sufficient mitigation measures would be in place to ensure that water quality would not be degraded substantially at the Wyoming/Montana border (Appendix B).

Alternative 2A

Under Alternative 2A, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Alternative 2A involves different water handling of the produced water in certain sub-watersheds, emphasizing discharge of CBM water to infiltration impoundments. Approximately 25 percent of the proposed wells would discharge produced water on the surface and 51 percent would discharge produced water to infiltration reservoirs. Thus, the volume of water discharged to surface drainages would be less than under Alternative 1 and is shown in Table 4-1. Projected CBM runoff compared with average annual runoff is shown in Table 4-2. Ten of eighteen sub-watersheds would receive produced water under this alternative.

Direct/Indirect Effects

Water quality effects would be similar to those described for Alternative 1, but proportionately lower due to the reduction in the volume of produced water being discharged to surface drainages.

Timing and Quantity of Stream Flows

CBM supplemented flows would increase slightly from baseline conditions under Alternative 2A, and the projected annual outflow of CBM produced water at the sub-watershed boundaries would be much less than under Alternative 1, as shown in Table 4–1.

Comparing projected outflow numbers at sub-watershed boundaries (Table 4–1) to annual minimum flows (Table 3-5), the Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods. The other four sub-watersheds may see noticeable increases in stream flows during low flow periods. These are the Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above under Alternative 1; however, the degree to which they may be impacted would be substantially less under Alternative 2A than under Alternative 1.

Increases and Decreases in Sedimentation

Due to less CBM produced water being discharged to surface drainages under Alternative 2A, the degree to which sedimentation would occur in rivers and streams would be significantly less than under Alternative 1, although the types of potential impacts would be similar.

The Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, Middle Powder River, and Upper Cheyenne River would not see noticeable increases in stream flows during low flow periods or increased sedimentation, and impacts to aquatic species would be minimal or non-existent. The other three sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Little Powder River, Antelope Creek, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation, but impacts would likely be noticeably less than under Alternative 1.

Increases and Decreases in Salt Concentrations

Changes in salt concentrations in surface waters receiving CBM produced water would also be less under Alternative 2A than under Alternative 1, although the types of potential impacts would be similar. Salinities may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2A. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2A.

Increases in Metals

Changes in metal concentrations in surface waters receiving CBM produced water would also be less under Alternative 2A than under Alternative 1, although the types of potential impacts would be similar. Metal concentrations may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2A. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2A.

Fuel and Drilling Fluid Spills

Potential fuel and drilling fluid spills would likely result in less of an impact to fish and macroinvertebrates under Alternative 2A than under Alternative 1 because there would be less CBM produced water available to convey pollutants to surface drainages.

Increases or Decreases in Species Diversity

Potential changes in species diversity would be similar to Alternative 1 under Alternative 2A, although they would occur at a lesser degree.

Alternative 2B

Under Alternative 2B, the same number of CBM wells and the same volume of water production would be projected as under Alternative 1. Alternative 2B involves different water handling of the produced water in certain sub-watersheds, emphasizing surface discharge of CBM water and discharge to infiltration impoundments. Approximately 40 percent of the proposed wells would discharge produced water on the surface and 37 percent would discharge produced water to infiltration reservoirs. Thus, the volume of water discharged to surface drainages would be less than under Alternative 1 but more than under Alternative 2B, and is shown in Table 4–1. Projected CBM runoff compared with average annual runoff is shown in Table 4–2. Ten of eighteen sub-watersheds would receive produced water.

Direct/Indirect Effects

Water quality effects would be similar to those described for Alternative 1, but proportionately lower due to the reduction in the volume of produced water being discharged to surface drainages.

Timing and Quantity of Stream Flows

Flows supplemented by CBM produced water would increase slightly from baseline conditions under Alternative 2B, and the projected annual outflow of CBM produced water at the sub-watershed boundaries would be less than under Alternative 1, with one exception (Table 4–1). Flow in the Upper Belle Fourche would increase above the predicted flow under Alternative 1 by approximately 32 percent.

Comparing projected outflow numbers at sub-watershed boundaries (Table 4–1) to annual minimum flows (Table 3–5), the Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods. The other five sub-watersheds may see noticeable increases in stream flows during low flow periods. These are Clear Creek, the Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above under Alternative 1; however, the degree to which they may be impacted would be substantially less under Alternative 2B than under Alternative 1, except in the Upper Belle Fourche River where impacts may be greater than predicted under Alternative 1.

Increases and Decreases in Sedimentation

Due to less CBM produced water being discharged to surface drainages under Alternative 2B, the degree to which sedimentation would occur in rivers and streams would be substantially less than under Alternative 1, although the types of potential impacts would be similar.

The Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, Middle Powder River would not see noticeable increases in stream flows during low flow periods or increased sedimentation, and impacts to aquatic species would be minimal or non-existent. The other four sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation, but impacts would likely be noticeably less than under Alternative 1.

Increases and Decreases in Salt Concentrations

Changes in salt concentrations in surface waters receiving CBM produced water would also be less under Alternative 2B than under Alternative 1, although the types of potential impacts would be similar. Salinities may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2B. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2B than under Alternative 1.

Increases in Metals

Changes in metal concentrations in surface waters receiving CBM produced water would also be less under Alternative 2B than under Alternative 1, although the types of potential impacts would be similar. Metal concentrations may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 2B, with the exception of the Upper Belle Fourche River, where affects would be more substantial. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 2B.

Fuel and Drilling Fluid Spills

Potential fuel and drilling fluid spills would likely result in less of an impact to fish and macroinvertebrates under Alternative 2B than under Alternative 1 because there would be less CBM produced water available to convey pollutants to surface drainages, with the exception of the Upper Belle Fourche River.

Increases or Decreases in Species Diversity

Potential changes in species diversity would be similar to Alternative 1 under Alternative 2B, although they would occur at a lesser degree.

Alternative 3

Under Alternative 3, no new Federal CBM wells would be completed. Water handling options would be the same as under Alternative 1. Water production would decline under Alternative 3. Thus, the volume of water discharged to surface drainages would be less than under Alternatives 1, 2A, and 2B as shown in Table 4–1. Projected CBM runoff compared with average annual runoff is shown in Table 4–2. Ten of eighteen sub-watersheds would receive produced water.

Direct/Indirect Effects

Water quality effects would be similar to those described for Alternative 1, but proportionately lower due to the reduction in the volume of produced water being discharged to surface drainages. Water quality changes due to CBM enhanced flows would be negligible (surface water section in Chapter 4).

Timing and Quantity of Stream Flows

Flows supplemented by CBM produced water would increase slightly from baseline conditions under Alternative 3, and the projected annual outflow of CBM produced water at the sub-watershed boundaries would be less than under Alternative 1 (Table 4–1).

Comparing projected outflow numbers at sub-watershed boundaries (Table 4–1) to annual minimum flows (Table 3–5), the Upper Tongue River, Upper Powder River, Salt Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods. The other six sub-watersheds may see noticeable increases in stream flows during low flow periods. These are Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above under Alternative 1; however, the degree to which they may be impacted would be substantially less under Alternative 3 than under Alternative 1.

Increases and Decreases in Sedimentation

Due to less CBM produced water being discharged to surface drainages under Alternative 3, the degree to which sedimentation occurs in rivers and streams would be substantially less than under Alternative 1, although the types of potential impacts would be similar.

The Upper Tongue River, Upper Powder River, Salt Creek, and Middle Powder River would not see noticeable increases in stream flows during low flow periods or increased sedimentation, and impacts to aquatic species would be minimal or non-existent. The other six sub-watersheds may see noticeable increases in stream flows during low flow periods that may noticeably increase sediment loads in these watersheds. These are the Crazy Woman Creek, Clear Creek, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Aquatic species in these sub-watersheds may be impacted, as discussed above, by an increase in sedimentation, but impacts would be noticeably less than under Alternative 1.

Increases and Decreases in Salt Concentrations

Changes in salt concentrations in surface waters receiving CBM produced water would also be less under Alternative 3 than under Alternative 1, although the types of potential impacts would be similar. Salinities may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 3.

Related impacts to fish and macroinvertebrates would therefore be less under Alternative 3 than under Alternative 1.

Increases in Metals

Changes in metal concentrations in surface waters receiving CBM produced water would also be less under Alternative 3 than under Alternative 1, although the types of potential impacts would be similar. Metal concentrations may change as described under Alternative 1, but these would occur to a lesser degree under Alternative 3. Related impacts to fish and macroinvertebrates would therefore be less under Alternative 3.

Fuel and Drilling Fluid Spills

Potential fuel and drilling fluid spills would likely result in less of an impact to fish and macroinvertebrates under Alternative 3 than under Alternative 1 because there would be less CBM produced water available to convey pollutants to surface drainages.

Increases or Decreases in Species Diversity

Potential changes in species diversity would be similar to Alternative 1 under Alternative 3, although they would occur at a lesser degree.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects on aquatic species in the Project Area. The proposed alternatives, combined with the potential for future CBM projects not addressed in this document, may lead to potential cumulative effects including fluctuations in stream flow, fluctuations in sedimentation, increases in salt concentrations, changes in water quality, increases in contaminants in waterways, changes in habitats, and changes in species diversity. Each alternative would contribute to cumulative effects in varying degrees, as discussed in the aquatic effects section.

Current major land uses in the Project Area include livestock grazing, agriculture, mining, CBM gas development, and conventional oil and gas development. The proposed Project would contribute to ongoing effects to aquatic life from all of these land uses.

In addition to an increase in flow in sub-watersheds that receive CBM produced waters, coal mines in the Project Area discharge water from pits into surface drainages. Coal mine records for activities within the Project Area indicate that water is generally discharged from pits only after storm events, at which time water quality in receiving waters is similar to discharge water. This would not affect sedimentation or water quality to a large degree, but would add to already increased instream flows during high runoff periods. Watersheds within the Project Area that have existing coal mines include Upper Cheyenne River, Upper Belle Fourche River, and Little Powder River. These cumulative impacts would affect aquatic species in the same ways as discussed above. After CBM development is completed, flows would return to the current flow regime.

The proposed Project would lead to an overall increase in sediment load in drainages within the Project Area and would contribute to increased sedimentation caused by the existing land uses in the area. Increased CBM produced flow and sedimentation related to the construction of new roads would be the primary contributor to increased sediment load in the drainage systems. Much of the sediment produced by the Project would be collected in ponds and reservoirs throughout the Project Area, and would likely be flushed through the drainage systems for years after the discharge of CBM water. Increased sediment load may also change or eliminate existing fish and macroinvertebrate habitats over the long term; these changes in habitat may favor exotic species over native species.

In addition to salts being added directly to surface drainages, CBM produced waters that do not reach drainages (e.g., containment, LAD, and injection) will evaporate and deposit salts in soils throughout the sub-watersheds. This accumulation of salts in the soils will continue as long as CBM produced water is discharged, and may be released into surface drainages and groundwater for years after the discharge of water ceases, further increasing salinity in surface drainages and potentially affecting fish and macroinvertebrates. Agriculture and livestock grazing are currently the primary sources of salt introduction, and CBM produced waters would contribute additional salts.

Water quality would continue to change throughout the Project Area both during and after the life of the Project, and would continue to affect aquatic life in drainages already affected by existing land uses. Long-term water quality effects that would likely continue after CBM wells cease water discharge include increased concentrations of selenium, bicarbonate and other salts, and sediment load; these could all potentially affect aquatic life.

All of the cumulative effects may influence current fish and macroinvertebrate species diversities. Long-term cumulative effects may alter water quality and fish habitats to the extent that exotic species can utilize these streams and rivers more effectively than native species, resulting in more exotic species and less native species.

Alternative 1

Under Alternative 1, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Salt Creek, Crazy Woman Creek, and Clear Creek, followed by the Upper Tongue River, Upper Belle Fourche River, Upper Cheyenne River including Antelope Creek, Little Powder River, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 1 would have the most cumulative impacts of the four alternatives.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Alternative 2A

Under Alternative 2A, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Crazy Woman Creek, and Clear Creek, followed by the Upper Belle Fourche River, Upper Tongue River, Upper Cheyenne River including Antelope Creek, Little Powder River, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 2A would have more cumulative impacts than Alternative 3, but less than Alternatives 1 and 2B.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Alternative 2B

Under Alternative 2B, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Crazy Woman Creek, and Clear Creek, followed by the Upper Belle Fourche River, Upper Tongue River, Upper Cheyenne River including Antelope Creek, Little Powder River, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 2B would have more cumulative impacts than Alternatives 2A and 3, but less than Alternative 1.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Alternative 3

Under Alternative 3, cumulative effects would be highest in the Powder River Basin, including the Upper Powder River, Crazy Woman Creek, and Clear Creek, followed by the Upper Belle Fourche River, Upper Tongue River, Little Powder River, Upper Cheyenne River including Antelope Creek, and Middle Powder River, respectively. This conclusion is based on the increase in surface water flows due to CBM produced water discharge and effects associated with these discharges that would contribute to cumulative effects. Alternative 3 would have the least amount of cumulative effects of all the alternatives.

The development of new roads would also contribute to cumulative effects in watersheds that will not receive discharged CBM water.

Threatened, Endangered, and Sensitive Species

Potential effects to special status species would be similar to those described for vegetation and wildlife species. The nature and extent of effects to a particular species would depend on that species' life history and habitats utilized. Direct effects to special status plant species would occur from the disturbance or removal of individuals or populations resulting from the construction of well pads, compressor stations, ancillary facilities, associated pipelines, water-handling facilities, and roads. Indirect effects to special status plant species would include: 1) an increase in the potential for spread of noxious weeds that displaces native plant populations, due to increased disturbance in the Project Area; and 2) alteration of suitable habitat distribution, due to changes in volume and rate of surface water flows, particularly changes in stream flow from intermittent to perennial.

Effects to special status wildlife species would include: 1) disturbance effects on individuals and populations by human activity; 2) the loss or reduction in effectiveness of habitats occupied by these species; 3) habitat fragmentation, particularly through construction of roads, well pads, and fences; 4) introduction of new perches for raptors and thus potential increase in local predation rates on some species; 5) increases in harassment; and 6) project-induced increase in mortality (e.g., poaching, trapping, poisoning, roadkills, raptor collision, raptor electrocution). The magnitude of effects to special status species would depend on a number of factors, including recommended and required mitigation measures.

Direct disturbance of special status species habitats would occur in each subwatershed and under each alternative. In an effort to return habitats to full use, unused portions of well sites would be reclaimed during the production phase. Following the end of the production phase, well field and ancillary facilities would be removed and disturbed areas reclaimed. Seed mixes approved by the appropriate agency, many of which are intended to be beneficial to wildlife species, would be used to revegetate abandoned well pads and areas occupied by ancillary facilities. The amount of time these lands are unsuitable as habitats is variable and may depend on one or more of the following: productive well lifespan, mitigation success, reclamation techniques, and local weather conditions. Reclamation of habitats dominated by grasses and forbs is expected to be successful within several years; habitats dominated by shrubs and trees may take eight to twenty years or more to successfully re-establish. Consequently, the disturbance of forest and shrub habitats would represent a long-term loss to those species that depend on such vegetation for forage or shelter beyond the end of the production phase.

Indirect effects, including displacement, would occur in varying degrees during construction, production, and reclamation phases of the Project. In response to the increased levels of human activity, equipment operation, vehicular traffic, and noise associated with all phases of the Project, species would avoid areas of these activities and utilize other locations. This avoidance would result in the under-utilization of otherwise suitable habitats; therefore the value of these habitats would be diminished. Additionally, distribution patterns would be altered and resource competition would be increased in unaffected habitats. The degree of habitat avoidance would vary among species and among individuals of any particular species.

Mitigation measures expected to eliminate or minimize potential effects to threatened and endangered wildlife and plant species are provided at the end of this chapter. Additionally, the Biological Assessment for species listed or proposed for listing by the USFWS is included as Appendix H.

Plant Species

U. S. Fish and Wildlife Service

Ute Ladies'-tresses Orchid

Direct and Indirect Effects

The potential for direct effects to this species would be minimal. There are no existing oil and gas wells in the upper portion of the Antelope Creek subwatershed near the known population occurrence of this species. None of the wells that are proposed as a part of this Project would be constructed near that location. There is the potential for other populations of this species to occur in the Project Area. Prior to construction, surveys of suitable habitats (i.e., wetlands and riparian areas) would be required. In addition, efforts would be made to avoid habitats suitable for this species. Because of the ability of this species to persist below-ground or above-ground without flowering, single season surveys that meet the current USFWS survey guidelines may not detect populations. As a result, part or all of undetected populations could be lost to surface-disturbing activities.

Indirect effects to currently undocumented populations of this species would occur as a result of hydrological alterations associated with the Project. The discharge of produced water would potentially alter the distribution and extent of riparian and wetland areas, with the net effect being an increase in the extent of these areas. This may provide additional suitable habitat for the Ute ladies'-tresses orchid in areas that are not currently suitable, while at the same time rendering unsuitable some habitat that is currently suitable. Groundwater depletion associated with CBM well de-watering could result in lowered water tables and loss of riparian and wetland vegetation in isolated area where the coal seams are near shallow alluviums. In some conditions, groundwater levels may be supplemented and not depleted following applied water handling methods. Increased groundwater levels may augment existing orchid habitats or create new suitable habitats. Effects along any particular drainage would depend on the amount, timing, and location of water discharge, stream geomorphology, precipitation, and other factors. Habitats and populations of this species may be affected by increased erosion or sediment deposition. Some streams would be greatly affected by discharge, while others would be affected only minimally or not at all.

Both direct and indirect disturbances to populations and habitats of the Ute ladies'-tresses orchid have the potential to increase the distribution and extent of noxious weeds, such as Canada thistle, that occur in similar habitats as this species. Dense populations of noxious weeds reduce the amount of habitat available to the orchid and could result in the exclusion of the orchid from infested areas.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to the Ute ladies'-tresses orchid as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of 15,458 CBM wells and 1,409 Non-CBM wells, potentially affecting the Ute ladies'-tresses orchid to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect the Ute ladies'-tresses orchid, which is also less than the other three alternatives.

Wildlife Species

U. S. Fish and Wildlife Service

Black-tailed Prairie Dog

Direct and Indirect Effects

The Project would have both direct and indirect effects on individuals and populations of the black-tailed prairie dog. Individuals and colonies would be impacted by construction of well pads, roads, pipelines, and other facilities. Increased availability of perches for raptor species would increase predation on prairie dogs. Fragmentation would reduce habitat availability in colonies, reducing habitat quality and reproductive potential in areas that are close to, or at, carrying capacity. Increased vehicle traffic would increase the potential for vehicle collisions, reducing population levels in colonies adjacent to existing and new roads. Shifts in vegetation types as a result of produced water discharges would reduce the amount of habitats available for burrows because prairie dogs do not dig burrows in wet or saturated soils. Expanded wetland and riparian areas within colonies would increase fragmentation and decrease habitat effectiveness.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to the black-tailed prairie dog as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM non-CBM wells, thus potentially affecting the black-tailed prairie dog to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 13,870 acres that could potentially affect the black-tailed prairie dog, which is also less than the other three alternatives.

Preble's Meadow Jumping Mouse

Direct and Indirect Effects

This species would not be affected by the Project because it does not occur in parts of the Project Area that would be impacted by development. Discharge of produced water to the North Platte River is expected to be minimal and would not affect the overall hydrologic regime of this large river system.

Alternative Comparisons

None of the alternatives would affect the Preble's meadow jumping mouse.

Black-footed Ferret

Direct and Indirect Effects

The potential for effects to the black-footed ferret are expected to be minimal. There are no known populations of this species in the Project Area. Most of the larger prairie dog colonies thought to be capable of supporting ferret populations have been surveyed to rule out presence of the ferret. Any colonies that meet the USFWS guidelines for potential black-footed ferret habitat that have not been previously surveyed would be surveyed for ferrets. No activities would occur in any colonies found to contain ferrets.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to suitable black-footed ferret habitat as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM and non-CBM wells, potentially affecting suitable black-footed ferret habitat to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect suitable black-footed ferret habitat, which is also less than the other three alternatives.

Bald Eagle

Direct and Indirect Effects

Bald eagles may be impacted in several ways. Changes in the availability of water and forage due to the Project activities may result in increased or new wildlife populations, such as big game, small mammals, upland birds, waterfowl, and passerines. An increase in wildlife populations within the Project Area, combined with the increase in volume and frequency of vehicular traffic, may result in an increase of vehicular collisions and roadside carcasses. Because bald eagles often forage on carcasses, a potential increase in carcasses may result in an increase of bald eagle foraging along roads within the Project Area. As the number of potential carcasses increases and the number of foraging eagles increases, so does the potential for vehicular collisions with bald eagles foraging on roadside carcasses.

New and additional levels of human disturbance in an area relatively void of human disturbance may have a negative effect to nesting and wintering bald eagles in the Project Area. Due to the current relative lack of human activity, bald eagles may exhibit sensitivities to activities of short duration and extent that would not otherwise affect bald eagles of other landscapes that are more accustomed to disturbance.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar number of CBM and non-CBM wells. Therefore, potential effects to the bald eagle as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM and non-CBM wells, potentially affecting the bald eagle to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect the bald eagle, which is also less than the other three alternatives.

Mountain Plover

Direct and Indirect Effects

The Project has the potential to have substantial adverse direct and indirect effects to the mountain plover. Direct loss of individuals and nests may occur as a result of vehicle collision and equipment operation in nesting areas. Chicks and eggs in nests may also be lost if disturbance or harassment occurs frequently, preventing adults from tending to chicks or nests and allowing excessive heating, chilling, or predation to occur. Frequent disturbance may lead to nest abandonment. Re-nesting may occur at another, less disturbed location, but a net loss in reproductive potential would have occurred with loss of the initial nest. Mountain plovers also show a high rate of nest site fidelity, often using the same general area year after year. Modifications that make these sites less suitable for nesting would result in decreased reproductive success. New nests may be placed in less suitable habitat, again resulting in potentially lower reproductive success.

Preferred nesting habitats, such as bare soil, may be created by construction and production activities. While providing habitat, these areas are also likely to result in nests being abandoned or destroyed when activities continue during the nesting season. The potential for this type of impact to occur would be greatest during the production phase, when limited intermittent activity would occur at well pads and along some access roads. Mountain plovers may arrive and begin nesting on bare ground in these areas, only to be disturbed or have nests destroyed the next time the road is used or well pad visited. This impact is most likely when activities occur at an interval of one week or more. During the construction phase, continuous activity is likely to prevent nest establishment in proximity to activities.

Indirect effects to mountain plovers would be caused by increased predator populations, especially of species that sometimes increase in areas impacted by humans, such as corvids (crows, ravens), raptors, coyotes, badgers, weasels, and foxes. New fences, transmission lines, and buildings would provide new perch and nest sites for avian predators, while buildings and other facilities would provide new denning sites for mammalian predators. Increased roadkills along new and existing roads would provide a food source that would allow increased predator populations that could also prey on mountain plovers.

Alternative Comparisons

Alternatives 1, 2A, and 2B each propose similar numbers of CBM and non-CBM wells. Therefore, potential effects to the mountain plover as a result of well pad construction under these alternatives would be similar. However, disturbances resulting from water handling methods are not equal between these alternatives. Alternative 1 would affect 32,685 acres, Alternative 2A would affect 51,579 acres, and Alternative 2B would affect 43,533 acres. Alternative 3 differs from the above alternatives in both number of wells and water handling methods. Alternative 3 would result in the addition of fewer CBM and non-CBM wells, potentially affecting the mountain plover to a lesser degree than Alternatives 1, 2A, and 2B. Water handling methods under Alternative 3 would result in the disturbance of 14,384 acres that could potentially affect the mountain plover, which is also less than the other three alternatives.

Boreal Western Toad

Direct and Indirect Effects

This species would not be affected by the Project because it is not known to occur, nor is it expected to occur, in the Project Area. Historically occupied habitats are all outside of the Project Area a substantial distance to the south and much higher in elevation. Potential indirect effects to this non-migratory species are not expected. Hydrological alterations would not occur do to the lack of hydrologic interconnection between the Project Area and suitable habitats for this species.

Alternative Comparisons

None of the alternatives would affect the boreal western toad.

Wyoming BLM and Forest Service

Many of the BLM and Forest Service Sensitive species that occur in the Project Area may be affected by the proposed Project. The extent of effects to any particular species are dependent on its life history, habitat preferences, adaptability to disturbance, and population levels in the portion of the Project Area that would be affected by the proposed Project. Because population levels of many sensitive species in the Project Area are unknown, and because the relationship between occupied areas and proposed Project activities are unknown, only the general types and levels of impacts can be determined. Table 4–94 lists the potential impacts of the proposed Project on each species and gives an estimate of the effect of these impacts on populations. Any identified mitigation measures for sensitive species are also listed in Table 4–94.

Cumulative Effects

Implementation of each of the alternatives would contribute to cumulative effects to both TES plant and wildlife species in the Project Area. One factor in the cumulative short- and long-term disturbance to TES plant and wildlife species would result from the direct effects of oil and gas (conventional and CBM) development. Additional oil and gas development (conventional and CBM), not included as part of this assessment, may also occur at a later date beyond the level of development considered in this analysis. Other activities contributing to cumulative effects to TES plant and wildlife in the Project Area include: coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing development.

On-going coal mining activities disturb surface lands at a rate of approximately 2,000 acres per year, with 1,850 acres successfully reclaimed on an annual basis. At present, approximately 54,000 acres have been disturbed by coal mining, while 20,200 acres have been successfully reclaimed. An unknown portion of disturbed coal mining area is currently under-going reclamation, but has not yet met success standards. A similar level of both new disturbance and reclamation success is expected in the near future. It is not known at this time which TES plant and wildlife species may be affected by this development.

Uranium mining has resulted in the disturbance of approximately 4,400 acres, while sand, gravel, and scoria mining has resulted in the disturbance of approximately 1,200 acres. Agriculture has resulted in impacts to approximately 113,643 acres of lands formally occupied by native vegetation that may be suitable to TES plants and wildlife. Urban development has resulted in the loss of approximately 4,362 acres of native vegetation that may be suitable TES plant and wildlife habitat. A minor amount of new rural and urban development is expected in the foreseeable future but no estimate of the amount or types of vegetation disturbance has been made. Cumulative impacts to vegetation from roads, railroads, and rural development have not been estimated.

Table 4–94 Wyoming BLM and Forest Service Sensitive Species Effects Evaluation

Species Name	Potential Effects	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
Plants					
Laramie Columbine	Not known to occur in project area.	No effect	No effect	No effect	No effect
Porter's Sagebrush	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Nelson's Milkvetch	Individual plants may be destroyed during development and production activities. Entire occurrences are unlikely to be destroyed.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Many-stemmed Spider-flower	Not known to occur in project area.	No effect	No effect	No effect	No effect
Wouldiams' Wafer-parsnip	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Cary Beardtongue	Not known to occur in project area.	No effect	No effect	No effect	No effect
Laramie False-sagebrush	Not known to occur in project area.	No effect	No effect	No effect	No effect
Soft Aster	Not known to occur in project area.	No effect	No effect	No effect	No effect
Northern Arnica	Not known to occur in project area.	No effect	No effect	No effect	No effect
Hall's Fescue	Not known to occur in project area.	No effect	No effect	No effect	No effect
Northern Blackberry	Not known to occur in project area.	No effect	No effect	No effect	No effect
Hapeman's Sullivantia	Not known to occur in project area.	No effect	No effect	No effect	No effect
Mammals					
Dwarf Shrew	Not known to occur in project area.	No effect	No effect	No effect	No effect
Long-eared Myotis	Habitat may be altered. Roost sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Fringed Myotis	Habitat may be altered. Roost sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Townsend's Big-eared Bat	Habitat may be altered. Roost sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Spotted Bat	Not known to occur in project area.	No effect	No effect	No effect	No effect
White-tailed Prairie Dog	Habitats may be altered or lost. Colonies may be fragmented. Individuals may be destroyed by construction and production related activities. Raptor predation may increase	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Water Vole	Not known to occur in project area.	No effect	No effect	No effect	No effect
Wolverine	Not known to occur in project area.	No effect	No effect	No effect	No effect
Swift Fox	Habitats may be altered, lost, or fragmented. Denning sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
American Marten	Not known to occur in project area.	No effect	No effect	No effect	No effect
Least Weasel	Habitats may be altered, lost, or fragmented. Denning sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Birds					
American Peregrine Falcon	Habitats may be altered. Nest sites may be disturbed. Foraging individuals	May affect[1]	May affect[1]	May affect[1]	May affect[1]

Table 4–94 Wyoming BLM and Forest Service Sensitive Species Effects Evaluation

Species Name	Potential Effects	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
	may be disturbed by development or production activities.				
American Bittern	Habitats may be altered by changes in hydrologic regime. Nest sites may be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
White-faced Ibis	Habitats may be altered by changes in hydrologic regime. Nest sites may be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Trumpeter Swan	Habitats may be altered by changes in hydrologic regime. Nest sites would not be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Northern Goshawk	Habitats would not be affected, because no activities would occur in occupied portion of project area.. Nest sites would not be disturbed. Individuals that move into affected portion of project area may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Merlin	Habitats may be altered. Nest sites may be disturbed. Foraging individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Upland Sandpiper	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Long-billed Curlew	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Yellow-billed Cuckoo	Habitats may be altered by changes in hydrologic regime. Nest sites may be disturbed. Individuals may be disturbed by development or production activities.	May affect[1]	May affect[1]	May affect[1]	May affect[1]
Burrowing Owl	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Lewis' Woodpecker	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Three-toed Woodpecker	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Loggerhead Shrike	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Golden-crowned Kinglet	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Pygmy Nuthatch	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Sage Thrasher	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Sage Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed.	May affect[2]	May affect[2]	May affect[2]	May affect[2]

Table 4–94 Wyoming BLM and Forest Service Sensitive Species Effects Evaluation

Species Name	Potential Effects	Alternative 1	Alternative 2A	Alternative 2B	Alternative 3
	Individuals may be destroyed by construction and production related activities.				
Baird's Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Brewer's Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Grasshopper Sparrow	Habitats may be altered, lost, or fragmented. Nest sites may be destroyed. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Amphibians					
Northern Leopard Frog	Habitats may be altered by changes in hydrologic regime. Breeding sites may be destroyed or created. Individuals may be destroyed by development or production activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Columbia Spotted Frog	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect
Wood Frog	Not known to occur in project area.	No effect	No effect	No effect	No effect
Reptiles					
Milk Snake	Habitats may be altered, lost, or fragmented. Individuals may be destroyed by construction and production related activities.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Fish					
Sturgeon Chub	Habitats may be altered by changes in hydrologic regime. Individuals and populations may be affected by changes in water quality and quantity.	May affect[2]	May affect[2]	May affect[2]	May affect[2]
Yellowstone Cutthroat Trout	No activities would occur in occupied portion of project area.	No effect	No effect	No effect	No effect

Notes:

1. Complete determination text reads as follows: "May adversely affect individuals, but not likely to result in a loss of viability on federal lands or range wide, nor result in a trend towards federal listing."
2. Complete determination text reads as follows: "May adversely affect individuals, may result in a loss of viability on federal lands or range wide, and may result in a trend towards federal listing."

The total acreage affected by CBM development would not be disturbed simultaneously, because Project development would occur over the life of the Project. Some of the disturbed acreage would be reclaimed or would be in the process of being reclaimed when new disturbances are initiated. CBM development is expected to occur at a rate faster than abandonment and reclamation of wells. In the near future, the amount of disturbed TES plant and wildlife habitats is likely to increase, although the anticipated life of CBM wells (12-20 years) indicates that reclamation would eventually overtake new well development, resulting in a net decrease in disturbed vegetation for the long-term.

Cumulative effects would also occur to TES plant and wildlife resources as a result of indirect impacts. One factor is the potential import and spread of noxious weeds around Project roads and facilities. Noxious weeds have the ability to displace native vegetation and hinder reclamation efforts. If weed mitigation and preventative procedures are applied to all construction and reclamation practices, the impact of noxious weeds on TES plants and wildlife would be minimized.

In areas reclaimed after CBM development, the reclaimed areas often differ substantially from undisturbed areas in terms of vegetation cover. Reclaimed areas may not serve ecosystem functions presently served by undisturbed vegetation communities and habitats, particularly in the short-term, when species composition, shrub cover, and other environmental factors are likely to be different. Establishment of noxious weeds and alternation of vegetation along drainages and reclaimed areas has the potential to alter TES plant and wildlife habitat composition and distribution. As a result, shifts in habitat composition or distribution may affect TES plant and wildlife species within the Project Area.

Cultural Resources

The goal of the consideration of historic properties under Section 106 of the National Historic Preservation Act of 1966 as amended (P.L. 89-665; P.L. 95515; P.L. 102-575; 80 Stat. 915; 16 USC 470), its implementing regulations, including but not limited to 36 CFR §800, 36 CFR §61, and Executive Order 11593, the National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852; 42 U.S.C. 1500-17.7; 42 U.S.C. 4321-61) and its implementing regulations including 40 CFR §1500-1508, is the preservation of the cultural values embodied in those historic properties. The BLM national cultural resource management objectives to meet the requirements of the latter statutory authorities and additional related authorities listed in BLM Manual M-8100.03 are:

A. Respond in a legally and professionally adequate manner to (1) the statutory authorities concerning historic preservation and cultural resource protection, and (2) the principles of multiple use.

B. Recognize the potential public and scientific uses of, and the values attributed to, cultural resources on the public lands, and manage the lands and cultural resources so that these uses and values are not diminished, but rather are maintained and enhanced.

C. Contribute to land use planning and the multiple use management of the public lands in ways that make optimum use of the thousands of years of land use history inherent in cultural resource information, and that safeguard opportunities for attaining appropriate uses of cultural resources.

D. Protect and preserve in place representative examples of the full array of cultural resources on public lands for the benefit of scientific and public use by present and future generations.

E. Ensure that proposed land uses, initiated or authorized by BLM, avoid inadvertent damage to Federal and non-Federal cultural resources.

The operational objectives to achieve this goal are:

1. Identification of all historic properties within the area of potential effect of proposed actions that are part of or associated with the federal undertaking;
2. Evaluation of the cultural values of those historic properties within appropriate historic contexts; and
3. Avoidance or minimization of adverse effects to those cultural values.

The cultural resources management objective of the BLM Buffalo Field Office, including stewardship considerations in addition to Section 106 and NEPA compliance is to "Protect, preserve, interpret, and manage significant cultural resources for their informational, educational, scientific, and recreational values" (BLM 2001:4).

These objectives are achieved through:

1. Inventory;
2. Evaluation;
3. Native American Consultation;
4. Management Options; and
5. Monitoring

Cultural resource sites are defined as discrete locations of past human activity, which can include artifacts, structures, works of art, landscape modifications, and natural features or resources important to history or cultural tradition. These sites can include extensive cultural landscapes (e.g., farm or ranch landscapes), linear landscapes (e.g., historic trails with associated towns, forts, and way stations), or railroad landscapes and traditional use areas. In this document, significant sites are defined as those sites that are listed on, determined eligible for, or recommended eligible for the National Register of Historic Places under the Criteria for Evaluation (36 CFR § 60.4), and sites that have not been evaluated.

Federal regulations require cultural resource inventory, recordation, and evaluation of resources in the area of potential effect as part of the approval process. All areas of proposed ground disturbing activity would be inventoried for cultural resources. Any discovered resources would be documented and evaluated for eligibility for the NRHP. With proper planning, effects to eligible properties can be avoided. Indirect effects from changes to soil stability or drainage patterns cannot always be anticipated. Indirect effects can be minimized by soil stabilization, fencing, or protective barriers to prevent inadvertent traffic in sensitive areas. Direct effects when eligible sites cannot be avoided would be subject to mitigation procedures. Adverse effects can be mitigated by implementation of approved data recovery treatment plans. There are a large number of unevaluated sites. These sites can be avoided or additional studies can be implemented to evaluate them. In addition, specific procedures would be established for the treatment of unanticipated discoveries and human remains that were not identified by surface investigation.

Adverse effects to cultural resources can result from the construction and operation of well pads, access roads, pipelines, power lines, and compressor stations and vehicular travel. Effects to sites can be direct as a result of construction or other earth disturbing activities, or can be indirect as a function of such things as increased erosion, easier access, vibration from traffic or machinery, or alteration of the setting. Adverse affects to cultural properties may include, alteration of visual, atmospheric, and auditory aspects of site setting, or site destruction by placement of facilities and infrastructure. Indirect effects can be particularly important in the consideration of sites that are important for their location, setting, and feeling, such as emigrant trails or locations of historic battles. Cultural sites are a nonrenewable resource and, if disturbed, lose potential information, integrity, and heritage value. Avoidance of eligible sites is the preferred mitigation. Although careful project planning can help alleviate inadvertent or unintentional effects to eligible sites, such effects can still occur. Data recovery plans can be undertaken in cases where eligible sites cannot be avoided or are unintentionally affected.

Native American Consultation

Effects to traditional cultural properties, localities of traditional concern, and sacred sites must be considered. Federal regulations require consultation with recognized Native American tribes. These include, but are not limited to:

National **H**istoric **P**reservation **A**ct of 1966, as amended (P.L. 89-665; P.L. 95-515; P.L. 102-575; 80 Stat. 915; 16 U.S.C. 470-470t; 36 CFR '60; 36 CFR '65; 36 CFR '800; 36 CFR '801; 36 CFR '61; Executive Order 11593). This requires federal agencies to consult with Indian tribes regarding federal undertakings in order to identify properties with tribal religious or cultural significance that may be eligible for the National Register of Historic Places (Traditional Cultural Places), and to determine ways to avoid or minimize effects to those properties.

National **E**nvironmental **P**olicy **A**ct of 1969 (P.L. 91-190; 83 Stat. 852; 40 U.S.C. 1500-17.7; 42 U.S.C. 4321-61; 43 CFR 1500-1508). This requires federal agencies to consult with Native American tribes regarding land use plans.

Federal **L**and **P**olicy and **M**anagement **A**ct of 1976 (PL 94-579; 90 Stat. 2743; 43 U.S.C. 1701). This provides Native American tribes and groups the opportunity to express their views and identify places of concern.

American **I**ndian **R**eligious **F**reedom **A**ct of 1978 (P.L. 95-431; 92 Stat. 469; 42 USC 1996 and 1996a; 43 CFR '7; Executive Order 13007). This requires federal land managing agencies to identify, through consultation, the concerns of traditional Native American religious practitioners, and to accommodate access to and ceremonial use of sacred sites.

Archaeological **R**esources **P**rotection **A**ct of 1979 (P.L. 96-95; 93 Stat. 721; 16 U.S.C 470aa-470mm; P.L. 100-555; P.L. 100-588). This requires consideration of Native American concerns and requires that federal land managing agencies notify appropriate tribes before approving permits for excavation of archaeological resources if the location may have cultural or religious importance to the tribes.

Native **A**merican **G**raves **P**rotection and **R**epatriation **A**ct of 1990 (P.L. 101-601; 104 Stat. 3048; 25 U.S.C. 3001; 43 CFR '10). Requires federal agencies to consult with appropriate tribes before the authorization of excavation or removal of Native American human remains and funerary objects with the purpose of determining how the tribes would like the agency to treat these remains.

In carrying out its mandated responsibilities, the Bureau of Land Management is obligated to ensure that the concerns that Native Americans have about federal land use plans are adequately addressed. The Bureau of Land Management must foster and maintain credible government-to-government relationships with Native American tribes.

Letters were sent to 26 tribes and various bands regarding the Powder River Basin Oil and Gas Environmental Impact Statement. Of the 26 tribes asked to participate, the Kiowa Tribe, Apache Tribe, Comanche Tribe, Teton Lakota Tribe, the Oglala Lakota Tribe, and bands of the Minneconjou, Siha Sapa, Oohenumpa, and Itazipco Lakota have expressed concerns and have asked to meet with BLM staff. These Native American groups have expressed concern over the handling of inadvertent discoveries of human remains, have asked for the opportunity to visit project areas to identify and interpret traditional cultural places, and have requested tribal monitoring of sensitive locations including archaeological sites. A meeting hosted by the Cheyenne River Sioux and attended by members of the Cheyenne River Sioux Tribe and Oglala Lakota Tribe was held in South Dakota in April 2001.

Treatments

The BLM, FS, and the State Historic Preservation Officer (SHPO) will develop a project treatment plan (outline in Appendix I). This plan would provide direction and decisions ahead of time so that actions in the field can be carried out much quicker, especially when unexpected discoveries are made. Mitigation of adverse impacts may include, site avoidance through project relocation or redesign, visual resource management including adjustment of the color of facilities, landform screening, detailed mapping and recordation, historic documentation, or data recovery.

Many areas of federal minerals in the Project Area are privately owned surface. The surface owners must be kept informed of activities that are planned on their property, including the identification and treatment of historic and prehistoric resources. They must also understand, or be reassured that resources on their property belong to them, and that they will have the option of taking possession of any cultural materials recovered on their land after the completion of appropriate documentation and analysis.

The following section briefly outlines several types of situations that may arise and potential options for dealing with those situations. These options will be discussed in more detail in the treatment plan.

Situation 1 — Unevaluated Sites:

Roughly 35 percent of the known sites in the Project Area are unevaluated. The reason that a particular site is unevaluated may include:

- The site was recorded formally or informally outside the Section 106 or NEPA processes and evaluation was not required;
- Site recording was incomplete or inadequate;
- Documentation of the historic context of the site was not pursued and information is inadequate for evaluation;
- The site is largely obscured (buried by sediment or covered by later construction episodes) and elements of the site must be uncovered to provide information for evaluation; or
- Comparative information on similar or related sites is insufficient or inadequately compiled.

If a site will be impacted by a proposed federal action it must be evaluated to determine whether it is a historic property. Depending on why the site is unevaluated it may require:

- A revisit and rerecording by current standards;
- Comparative or technical analysis of artifacts, materials, photographs, or information already gathered from the site;
- A search of public, historical or archival records to establish context and associations;
- Test excavation or partial removal of overlying fabric and structures to establish the nature and integrity of the site;
- A search of archival maps, photographs, or records to clarify earlier identity, appearance, location, or extent of a feature, building or structure; or
- Compilation of comparative data on similar or related sites.

If the effort necessary to adequately evaluate a site is excessive in comparison with the scale of the proposed action, it may be prudent to modify the proposed action to avoid the site as if it were eligible. However, it will still be necessary to verify the extent of the site and its contributing elements. If the site is unevaluated it can be difficult to adequately plan for avoidance and protection, because part of the process of evaluation is identifying the contributing elements or characteristics of the site that need to be protected.

Situation 2 — Resources that are Eligible for their Potential to Yield Important Information

Eligibility

Historic or prehistoric artifact scatters, artifacts with surface features, or buried levels that are eligible primarily for the information they may yield (Criterion d).

Impacts

- Mechanical disturbance by earth moving activities, surface traffic, erosion, or destabilization resulting in: loss of artifacts or features; loss of the context, patterning, or internal association of artifacts and features; or loss of specialized evidence (e.g., chemical, pedological, chronometric, geomorphic) integral to the information potential of the property.
- Deterioration through neglect.
- Intentional or inadvertent displacement, mixing, or removal of site elements.

Management

- Avoidance and protection during development by stipulation of limited activity, fencing or protective barricades, and monitoring – either the entire property or contributing areas within the property.
- Prevention of erosion, sedimentation, or indirect displacement by sediment stabilization, silt fences, or other appropriate measures – both development and post-development.
- Permanent fencing after development to exclude casual traffic and grazing disturbance.
- If avoidance and protection is not feasible, or site is inadvertently damaged, approved data recovery of elements of the site that make it eligible and are threatened.

Situation 3 — Resources Eligible for their Associations

Eligibility

Properties or extensive landscapes eligible for association with an event or pattern of events important in prehistory or history or the significant contributions of a person or being important in history or tradition that is integrally associated with the location, setting and feeling, with or without artifacts, features, structures, or buildings (Criteria a and b).

Impacts

- Mechanical, visual, or auditory disturbance to the location and setting that impairs the essential character of the property that conveys the important event, pattern of events, or setting in which an important person or being developed or delivered an important contribution to history or tradition.
- Indirect or delayed disturbance by destabilization of the landscape or introduction of aggressive plants or animals out of character with the historic setting.

Management

- Avoidance and protection during development and operation of the essential character of the location and setting of the property by limitation of extent and duration of activities, fencing or protective barricades, and monitoring of the immediate property and essential elements of its location and setting including any appropriate buffer.
- Stipulations on development and operation of facilities and access to facilities so that intrusion on the essential character of the property is minimized – including minimum proximity for development and traffic, restriction of noise, restriction of activities within view of the property, or use of construction materials, styles, and colors that are in character with the setting.
- Protective measures and monitoring to prevent significant changes in vegetation, hydrology, or soil stability.
- Unavoidable impact might be mitigated by an approved plan of recordation, or recordation and restoration of the essential character and setting of the property.

Situation 4 — Resources Eligible for their Design, Materials, Workmanship or Artistic Value

Eligibility

- Properties eligible as non-portable art, architecture, or designed structures (Criterion c).
- In many cases the location, setting and feeling of these objects, buildings or structures may also be essential elements of their significance.

Impacts

- Direct mechanical damage to the essential character of the object, building or structure.
- Indirect damage or deterioration to essential design, materials, or workmanship by destabilization of underlying materials, structural vibration, dust, or damaging fumes. These might include erosion, acceleration of structural deterioration, deterioration of the underlying substrate of rock art, deterioration or corrosion of pigments or surface materials, or deposition of intrusive sediments or materials.

- Mechanical, visual, or auditory disturbance to the location and setting that impairs the essential character of the property.

Management

- Avoidance and protection during development and operation of the essential character of the object, building or structure, and of the location and setting of the property by limitation of extent and duration of activities, fencing or protective barricades, and monitoring of the immediate property and essential elements of its location and setting including any appropriate buffer.
- Stipulations on proximity, extent, and duration of traffic and activities during development and operation in order to control vibrations, dust, exhaust, and fumes that might damage or disturb the essential character of the property.
- Periodic monitoring of compliance with stipulations and the effectiveness of those stipulations.
- Stabilization of structure or underlying materials.
- Control measures to minimize dust and fumes.
- Protective materials or barriers to control the movement of intrusive or damaging materials.
- Unavoidable impact might be mitigated by detailed recordation; relocation of the object, building or structure if its location and setting are not primary essential elements of its significance; or repair and restoration.

Project Alternatives

The Project Area has been divided into 18 sub-watersheds for the purpose of analysis. The total square miles, square miles surveyed, percent surveyed, and average sites per square mile by watershed are shown in Table 4–95. The amount of land involved varies greatly by watershed with the largest amount of acreage in the Upper Powder River watershed and the smallest in the North Fork Powder River. As expected, the surveyed areas and percent of area surveyed also varied greatly. Figure 4–43 shows sections in the Project Area that have had intensive surveys and the relative density of sites recorded. The average percent of area surveyed for the total Project Area is 10.2 percent with a high of 40.6 and a low of 0.7 percent. The number of sites per square mile for the total Project Area is 6.1 with the largest number of sites per square mile found in the Clear Creek sub-watershed and the smallest in the Upper Belle Fourche River sub-watershed. The Clear Creek sub-watershed is a diverse area that is likely to have a high site density. However, in this table, the site density is also inflated by thematic surveys that reported sites, but have no associated survey acreage. The total number of sites recorded in all the watersheds appears low, but is likely a result of the amount of surveyed acreage being low rather than indicating a low site density. The most common sites in the Project Area are prehistoric artifact scatters and rural historic sites.

Table 4–95 Previously Surveyed Area and Average Density of Known Cultural Resource Sites per Square Mile by Sub-watershed

Sub-watershed	Total Square Miles	Square Miles Surveyed	Percentage Surveyed	Sites per Square Mile
Little Bighorn River	77.5	0.6	0.7	13.3
Upper Tongue River	1,156.1	33.7	2.9	13.3
Middle Fork Powder River	725.7	23.8	3.3	22.2
North Fork Powder River	32.3	0.4	1.3	15
Upper Powder River	2,505.5	229.4	9.2	5.0
South Fork Powder River	178.7	5.3	3.0	7.4
Salt Creek	238.1	11.3	4.7	7.9
Crazy Woman Creek	856.7	7.9	0.9	21.3
Clear Creek	855.4	6.7	0.8	45.2
Middle Powder River	350.4	31.9	9.1	5.2
Little Powder River	1,352.3	158.6	11.7	4.6
Little Missouri River	60.2	2.7	4.5	10.7
Antelope Creek	1,031.7	206.4	20.0	4.7
Dry Fork Cheyenne River	483.3	64.0	13.2	8.9
Upper Cheyenne River	323.1	131.2	40.6	5.2
Lightning Creek	481.8	62.2	12.9	4.5
Upper Belle Fourche River	1,320.1	245.3	18.6	4.3
Middle North Platte River	332.2	41.0	12.4	7.7
Total	12,361.1	1,262.4	10.2	
Average				6.1

For planning purposes, it is assumed that the areas that have been inventoried for cultural resources in each sub-watershed are representative of the range of settings in the respective sub-watersheds. It is further assumed that cultural resource sites are randomly distributed across the landscape. Given the total number of previously recorded sites per square mile for each watershed, the number of sites expected in the remaining unsurveyed areas can be estimated. Figure 4–43 shows the estimate of square miles of total disturbance as a result of the Proposed Action and each Alternative and the number of cultural resource sites that may be affected by the proposed disturbance in each sub-watershed for the four alternatives.

Figure 4–43 Distribution of Intensive Surveys and the Relative Density of Cultural Sites Recorded

Alternative 1

Alternative 1 is the Proposed Action. The total square miles of potential impact is 329.3. The number of sites per square mile from Table 4–96 is used as a multiplier to estimate the number of sites in the area of potential effect given the square miles of new disturbance. The potential number of sites affected by watershed varies from a high of 1,200 to a low of zero where there is no proposed development. All areas of ground disturbance associated with federal actions would be surveyed for cultural resources during the APD process. Until those surveys are completed, only rough estimates can be made of the actual number of eligible cultural resource sites that would be affected by the proposed oil and gas development and the nature of those effects.

Table 4–96 Estimated Square Miles of Total CBM Surface Disturbance and Potentially Affected Cultural Resource Sites by Sub-watershed and Alternative

	Alternative 1		Alternative 2A		Alternative 2B		Alternative 3	
Sub-watershed	Square miles	Sites	Square Miles	Sites	Square Miles	Sites	Square miles	Sites
Little Bighorn River	0	0	0	0	0	0	0	0
Upper Tongue River	17.6	236	18.9	253	17.6	236	14.5	194
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Upper Powder River	109.7	549	128.9	645	123.1	616	30.8	154
South Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	1.8	14	1.9	15	1.9	15	0.5	4
Crazy Woman Creek	22.6	479	26.4	565	25.0	535	7.9	169
Clear Creek	27.3	1,234	29.5	1,333	27.7	1,252	18.3	827
Middle Powder River	6.3	32	7.1	37	6.7	35	1.5	8
Little Powder River	24.0	110	25.7	118	24.6	113	12.4	57
Little Missouri River	0	0	0	0	0	0	0	0
Antelope Creek	70.4	401	70.9	404	70.6	402	25.9	148
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Upper Cheyenne River	5.2	27	5.4	28	5.2	27	2.4	12
Lightning Creek	0	0	0	0	0	0	0	0
Upper Belle Fourche River	48.0	206	48.0	206	47.4	204	28.5	123
Middle North Platte River	0	0	0	0	0	0	0	0
Total	332.9	3,288	362.7	3,604	349.8	3,435	142.7	1,696

Alternative 2

Alternative 2 differs from the Proposed Action in the methods of boosting compression and the strategies for produced water management. Although the number of proposed new wells to be developed in Alternative 2 is the same as the Proposed Action, the area of potential disturbance presented for Alternative 2 in Table 4–96 is different than that presented for the Proposed Action. Alternative 2 also includes two methods for handling produced water (2A and 2B), which differ slightly in the area that would be disturbed.

The total square miles of potential impact for Alternative 2A is 358.5. The number of sites per square mile from Table 4–95 is used as a multiplier to estimate the number of sites in the area of potential effect given the square miles of new disturbance. The potential number of sites affected by watershed varies from a high of 1306 to a low of zero where there is no proposed development. Alternative 2B would result in less total surface disturbance (346.4 square miles) and slightly fewer cultural resource sites affected. All areas of ground disturbance associated with federal actions would be surveyed for cultural resources during the APD process. Until those surveys are completed, only rough estimates can be made of the actual number of eligible cultural resource sites that would be affected by the proposed oil and gas development.

Alternative 3

This alternative would result in no new federal wells. There would still be effects from development, drilling, and operations on private or state land. Some of the roads and water handling facilities would be located on federal lands. Federal agencies would allow these effects. Consequently, a small amount of federal land would be affected by private development in Alternative 3. The total square miles of potential effect for Alternative 3 is 141.1. The number of sites per square mile from Table 4–95 is used as a multiplier to estimate the number of sites in the area of potential effect given the square miles of new disturbance. The potential number of sites affected by watershed varies from a high of 818 to a low of zero where there is no proposed development. All areas of ground disturbance associated with federal actions would be surveyed for cultural resources during the APD process. Until those surveys are completed, only rough estimates can be made of the actual number of eligible cultural resource sites that would be affected by the proposed oil and gas development.

Management Options

Because of the requirements for compliance with federal regulations including, but not limited to Section 106 of the National Historic Preservation Act, the National Environmental Policy Act, and the Archeological Resources Protection Act, all areas on Federal lands and mineral proposed for disturbance will be inventoried for cultural resources. Procedures and standards for identifying, evaluating, and protecting cultural resources under federal jurisdiction would be spelled out in the treatment plan. Equivalent regulatory mandates are not in place for private or State of Wyoming lands. However, if a project involves a Federal permit or authorization, Federal historic preservation requirements will apply.

It is evident that all of the alternatives will result in adverse effects to large numbers of historic properties. As development progresses the opportunities for avoiding direct or indirect effects to historic properties will diminish. As more wells are developed it will become increasingly difficult to avoid visual and auditory impacts to cultural landscapes. Because of long-term planning and management considerations, cultural resource inventories should target entire plans of development (PODs) rather than piecemeal actions.

The following types of management situations will be encountered:

1. The resource is not a historic property, no further work is required;
2. The historic property is within an area of proposed disturbance, but the proposed action can be altered within areas of existing inventory to avoid direct adverse effects and protect the property from indirect adverse effects;
3. The historic property is within an area of proposed disturbance but the proposed action can be altered, relocated, or constrained within areas of existing inventory so that only non-contributing portions of the historic property are affected and contributing portions can be protected from adverse impact;
4. The historic property is not immediately within the area of proposed impact, but its location and setting are intrinsic to its eligibility, and the proposed action can be altered, relocated, or constrained in such a way that its intrusion upon the viewshed and adverse effect contributing aspects of the setting can be minimized;
5. The historic property is within an area of proposed impact but is a small property eligible under Criteria c or d and the property itself, its significant attributes, or its important data are not intrinsically tied to their location or setting and can be moved, collected, documented, or studied at minimal cost; or
6. The historic property and feasible design of the proposed action are such that avoidance and protection of the property is not a viable alternative. In such a case the cultural resource professional will propose a prudent and feasible recordation or data recovery plan to submit to BLM for review.
7. The historic property was not identified or predicted by the cultural resource inventory and was encountered during development or operation of the facilities.

The treatment plan would discuss management strategies that can be applied to the latter situations to expedite the management process. It also would specify monitoring strategies that will assess the effectiveness of management strategies in achieving preservation objectives. If management activities are not achieving their objectives, the strategies and stipulations would be modified to improve their effectiveness.

Land Use and Transportation

Land Use

This section discusses the potential effects to land ownership, land uses, and land management plans in the Project Area.

Land Status/Ownership

Surface or mineral ownership would not be expected to change by implementation of any of the alternatives. No direct or indirect effects to existing surface land ownership or mineral ownership would occur under implementation of any of the alternatives.

Surface use and rights-of-way approvals would be obtained from appropriate federal, state, and local agencies. Access easements would be negotiated with landowners or secured through the permitting processes of the federal, state, or local jurisdictional agencies. For Alternative 1 and Alternative 2, most of the proposed wells and ancillary facilities would be located on lands for which the federal government owns the CBM mineral estate. However, not all of the surface ownership may be federally owned.

Land Use

This section discusses the short-term and long-term direct and indirect adverse effects to existing land uses that are anticipated to occur from Project implementation.

Direct and Indirect Effects

Rangeland/grazing is the primary land use that would be affected by any of the alternatives for both public and private lands in the Project Area. Direct effects to land uses result from the removal or loss of existing land uses due to direct disturbances for the Project-related facilities or activities, and occur at the same time and place as the project-related action. Indirect effects to land uses are reasonable foreseeable results of the Project-related activities that occur at a later time, or are removed in distance from the project-related action. For example, project-related activities may generate noise, dust, traffic, visual intrusion of project-related facilities or activities, and/or add new access roads into limited use areas, indirectly affecting land uses for nearby properties and/or in the regional area. Indirect effects result if the project-related activities are incompatible with the land uses adjacent to the project-related disturbance areas, and may potentially change regional land use development patterns. CBM facilities are generally considered to be incompatible with residential land uses. The compatibility effects to residential areas from CBM facilities vary based on distance, topography, vegetation, and type of facilities.

Both short-term and long-term direct adverse effects to land uses are anticipated to occur from implementation of the any of the alternatives, as a result of the surface disturbances related to construction and operation of the proposed facilities.

Short-term direct effects to rangeland/grazing and other land uses would primarily occur during the construction and installation phase for any of the alternatives. Long-term direct effects would result from displacement of existing land uses for the life of the Project facilities for implementation of any of the alternatives. After decommissioning, reclamation, and final closure of the proposed facilities, the pre-existing land uses would be re-established.

Long-term indirect adverse effects would occur to the land uses on properties adjacent to the Project-related facilities from implementation of any of the alternatives due to the generation of dust and noise, visual and aesthetic effects of the project-related facilities and activities, increased traffic levels from project-related vehicles, and increased public access opportunities as a result of the development of new and upgraded access roads for the life of the Project.

Short-term indirect adverse effects would also occur to the land uses on properties adjacent to the Project-related facilities due to the physical intrusion of the construction crew and equipment, and the temporary obstruction or delay of traffic at road crossings during the construction and installation phase of any of the alternatives.

Alternative 1

Effects to land uses are addressed for the three primary phases of the Proposed Action: drilling and construction of facilities (short-term disturbances), production and maintenance (long-term disturbances), and decommissioning/reclamation. The overall life of the Project, including drilling, production, and reclamation is expected to be 20 years. The productive life of a single well is expected to be seven years. Within two or three years following the end of production, final reclamation of the wells would occur. After decommissioning, reclamation, and final closure of project-related facilities, the pre-existing land uses would be reestablished.

The land use disturbances associated with the Proposed Action include two primary components. The first is the CBM wells and their ancillary facilities. The second component is the non-CBM wells and their ancillary facilities.

Under the Proposed Action, wells and ancillary facilities would be installed and operated within 10 of the 18 sub-watersheds that comprise the Project Area. Most of the new wells (63 percent) and facilities would be constructed in two sub-watersheds: the Upper Powder River and Upper Belle Fourche River sub-watersheds. Other sub-watersheds with relatively high numbers of wells and facilities include Clear Creek, Crazy Woman Creek, Upper Tongue River, and Little Powder River.

Rangeland/grazing is the predominant land use that would be displaced by the project-related facilities for both the short term and long term. Short-term direct effects to existing land uses in the Project Area would result from the clearing of or damage to vegetation and disturbance of soils for the construction and installation of the proposed facilities associated with the Proposed Action. Long-term direct effects would result from displacement of the existing land uses for the production and maintenance activities that would occur for the life of the Project.

For the CBM wells, implementation of this alternative would cause short-term disturbance of as many as 211,992 acres. The short-term disturbance associated with Alternative 1 would involve about 3 percent of the almost 8 million-acre Project Area. Under the Proposed Action, surface disturbances and effects to existing land uses would occur during drilling and construction of the proposed facilities, including well pads, CMFs, roads, pipelines, power lines, compressor stations, and impoundments. Most of the short-term disturbance would be associated with the construction of the pipelines, roads, and water-handling facilities. Compressor stations would account for a small portion of the overall disturbance.

After installation of the proposed facilities, much of the disturbed land would reclaimed, revegetated, and returned to pre-existing land uses. Following reclamation of pipelines and partial reclamation of well pads and compressor stations, long-term disturbance associated with the new CBM wells would encompass about 108,799 acres. The acreage for long-term disturbance is a 45 percent reduction from the short-term disturbance. The roads and water handling facilities would comprise most of the long-term disturbance.

Under the Proposed Action, approximately 6,657 and 10,619 miles of new improved and two-track roads would be constructed, respectively. In the short-term, construction of improved roads would disturb approximately 12,965 acres, and construction of two-track roads would disturb 51,486 acres.

Of the total disturbance, short-term and long-term disturbances associated with the well pads for the Proposed Action are 10, 474 acres and 3,938 acres, respectively. The disturbances associated with the various pipelines for the Proposed Action would be short-term. Following reclamation of the pipelines, no long-term disturbance is anticipated. Reclamation would begin immediately after installation of underground pipelines.

A large portion of the disturbances associated with the Proposed Action are associated with the large upland reservoirs that would be constructed to contain the produced water over the life of the Project. Approximately 32,685 acres of total surface area would be disturbed both short-term and long-term for the water handling facilities for the Proposed Action. Each reservoir would have a total disturbance area of approximately 140 acres. Most of this disturbance would occur within the Upper Powder River and Upper Belle Fourche River sub-watersheds.

In addition to the disturbances associated with the CBM wells, about 3,200 non-CBM wells would also be completed over a 10-year period as part of the Proposed Action. Of these wells, 3,000 would be drilled within the Buffalo Field Office Area, and 200 wells to be located within the Casper Field Office Area. The projected maximum disturbance due to non-CBM wells is 5.5 acres and 4.5 acres per well for short-term and long-term disturbances, respectively. Short-term disturbance associated with the construction of non-CBM wells would affect almost 17,600 acres of the Project Area. Most of this disturbance would occur in three watersheds: Little Powder River, Upper Belle Fourche River, and Upper Powder River. Once the non-CBM wells are operational and partial reclamation has occurred, the long-term disturbance would be reduced to approximately 82 percent of the original disturbance, or approximately 14,402 acres.

Long-term indirect adverse effects to the land uses on properties adjacent to the Project-related facilities would occur from implementation of the Proposed Action due to the generation of dust and noise, visual and aesthetic effects of the project-related facilities and activities, increased traffic levels from project-related vehicles, and increased public access opportunities as a result of the development of new and upgraded access roads for the life of the Project. Short-term indirect adverse effects to the land uses on properties adjacent to the Project-related facilities would also occur due to the physical intrusion of the construction crew and equipment, and the temporary obstruction or delay of traffic at road crossings during the construction and installation phase of the Proposed Action.

Alternatives 2A and 2B

With the exception of the overall methods for handling the disposal of produced water, the land use effects associated with implementation of Alternative 2 are similar to those for the Proposed Action. Compared to Alternative 1, the changes in water handling methods included as part of this alternative slightly lower the number of acres that would be disturbed for both the short-term and long-term if this alternative is implemented.

For Alternative 2A, short-term disturbance would be approximately 248,485 acres of total surface area. Long-term disturbance associated with Alternative 2A would be 142,095 acres. Much of this long-term disturbance is associated with approximately 51,579 acres of surface area that would be disturbed for the water handling facilities to contain the produced water from the proposed CBM wells.

For Alternative 2B, short-term disturbance would be approximately 240,459 acres of total surface area. Long-term disturbance would be 134,069 acres, of which 43,553 acres would be associated with the water handling facilities.

For both Alternative 2A and Alternative 2B, rangeland/grazing is the predominant existing land use that would be displaced by the project-related facilities for both the short-term and long-term effects.

Alternative 3

Under this alternative, development of non-federal CBM wells would continue to occur on non-federal lands within the Project Area. The agencies assumed development of private and state minerals would occur along the same overall schedule as for Alternative 1. The Companies would drill approximately 15,458 new CBM wells between 2002 and 2011. These wells would be in addition to the 12,077 CBM wells already permitted or drilled on federal, state, and private lands within the Project Area. A total of 27,535 CBM wells would be developed by 2011 under this alternative.

As described under Alternative 1 and Alternative 2, some of the new CBM wells would be drilled from the same well pads; therefore, the number of pads constructed would be less than the number of wells drilled. A total of 10,534 new well pads would be constructed between 2002 and 2011. Including the 9,592 pads constructed or permitted prior to 2002, implementation of Alternative 3 would result in a total of 20,126 well pads by 2011.

Because fewer new wells would be drilled and fewer pads constructed, the number of facilities constructed would be smaller than under the Proposed Action. The overall short-term and long-term disturbances associated with this alternative would be less than that which would occur with implementation of Alternative 1 or Alternative 2.

Short-term direct adverse effects to land uses would result from the clearing of or damage to vegetation and disturbance of soils for the drilling and construction of facilities associated with any of the alternatives. For Alternative 3, short-term direct effects associated with the CBM wells would displace approximately 90,807 acres from the existing land uses, primarily rangeland/grazing. In addition, almost 17,599 surface acres would be disturbed by construction of non-CBM wells. Most of this disturbance would occur in three sub-watersheds. They are the Little Powder River, Upper Belle Fourche River, and Upper Powder River.

Long-term direct effects to land uses would result from the production and maintenance activities for the life of the Project. Once the CBM wells are operational and partial reclamation has occurred, long-term direct effects associated with the CBM wells would displace approximately 45,057 acres from the existing land uses, primarily rangeland/grazing. Approximately 14,384 acres of the total long-term disturbance would be displaced for the water handling facilities to contain the produced water from the proposed CBM wells. The long-term disturbance from the non-CBM wells is estimated to be an additional 6,339 acres.

Under Alternative 3, the existing land uses in the Project Area would continue to receive long-term indirect adverse effects would occur due to the generation of dust and noise, visual and aesthetic effects of the project-related facilities and activities, increased traffic levels from project-related vehicles, and increased public access opportunities as a result of the development of new and upgraded access roads for the life of the Project. Short-term indirect adverse effects to the land uses on properties adjacent to the Project-related facilities would also occur due to the physical intrusion of the construction crew and equipment, and the temporary obstruction or delay of traffic at road crossings during the construction and installation phase of any of the alternatives.

Consistency with Land Use Plans

Implementation of either Alternative 1 or Alternatives 2A and 2B would be consistent with land use plans of the State of Wyoming, the planning goals of the four counties, and planning goals of numerous incorporated areas within the Project Area. The results of the analysis of federal land use plans are presented in Chapter 5.

Although some of the proposed wells are within or near incorporated areas, primarily near the City of Gillette, zoning regulations allow oil and gas development within designated zoning districts. CBM facilities are generally considered to be incompatible with residential land uses. The degree of compatibility of CBM facilities adjacent to residential areas varies based on distance, topography, vegetation, and type of facilities.

Cumulative Land Use Effects

Under Alternative 1 or Alternatives 2A and 2B, the Companies would drill, complete, and operate an additional 39,367 new CBM wells within the Project Area by the end of 2011. Including the 12,077 CBM wells already permitted in the Project Area, Alternative 1 or Alternative 2 would have a cumulative total would of 51,444 new CBM wells, and 3,200 non-CBM wells within the Project Area by the end of 2011. The life of the Project for either of the action alternatives would be 20 years, and project-related activities would be completed around 2021.

Under Alternative 3, the Companies would drill approximately 15,458 new non-federal CBM wells between 2002 and 2011. These wells would be in addition to the 12,077 CBM wells already permitted or drilled on federal, state, and private lands within the Project Area. A cumulative total of 27,535 CBM wells would be developed by 2011 for this alternative.

Under any of the alternatives, the existing land uses would be temporarily displaced by the Project-related facilities over the life of the Project, primarily at CMFs, compression facilities and the water handling facilities where other uses would be fenced out.

Based on a comparison of acres of the total surface area disturbed for the Project facilities associated with each alternative, both short-term and long-term direct and indirect land use effects would be substantially less for Alternative 3, than for Alternative 1 or Alternative 2. Short-term disturbance associated with the CBM wells for Alternative 1 would affect approximately 230,703 acres. For Alternative 1, Alternative 2A, and Alternative 2B, the short-term disturbance associated with the non-CBM wells is estimated to affect approximately 17,599 acres. The short-term and long-term disturbances associated with Alternative 2A are estimated to affect approximately 232,180 acres and 128,987 acres, respectively. Alternative 2B would result in disturbances of approximately 223,934 acres and 120,741 acres over the short term and long term, respectively. Under Alternative 3, short-term and long-term disturbances would affect approximately 91,275 acres and 45,525 acres, respectively.

Transportation

This section discusses the potential effects to the transportation resources within the Project Area.

Effects to transportation resources are addressed for the three primary phases for each of the alternatives: construction and installation, operation and maintenance, and decommissioning/reclamation. The productive life of a single well is expected to be approximately 7 years. Within two or three years following the end of production, final reclamation of the wells would occur. The overall life of the Project, including drilling, production, and reclamation is expected to be 20 years.

Effects on the existing transportation system and traffic levels in the affected sub-watersheds would vary between the initial short-term construction and installation period (approximately one to two years for a given area), and the long-term operation and maintenance period for the life of the Project (20 years).

For any of the alternatives, prior to the construction of any new roads that are to access an existing state or county road, an access permit must be obtained from the Wyoming DOT. The application form for an access permit must include location of proposed road construction, and roadway design specifications, including type of surface material, drainage structures, roadway width, profile and grades.

Rail service and airports within the Project Areas would not be impacted by any of the alternatives. Drilling operations for any of the alternatives would comply with the Federal Airport Regulation Sub-Part 77 (FAR Part 77) requirements. Obstructions to air navigation are defined as any structure that is 200 feet in height above ground level or above the established airport elevation, whichever is higher, and within three miles of the established airport reference point. The FAA Form 7460-1 “Notice of Proposed Construction of Proposed Construction or Alternation” is required to be submitted to FAA at least 30 days before construction activities near an airport.

Assumptions of transportation-related impact analysis:

- The construction and installation phase for any of the alternatives would occur within the entire Project Area over approximately a 10-year period. Short-term and long-term increases in daily traffic would result from the proposed activities for any of the alternatives.
- Equipment needed for construction and installation of the proposed facilities for any of the alternatives would include heavy equipment (mobile drilling rig, bulldozers, graders, track hoes, trenchers, and front-end loaders), and heavy- and light-duty trucks.
- Short-term increases in daily traffic were assessed for all the alternatives based on the daily travel of the average number of estimated workers for the construction and installation phase of the proposed facilities, and would occur for approximately 10 years over the entire Project Area.
- Long-term increases in daily traffic were assessed for all alternatives based on the daily travel of the average number of estimated workers for the operation and maintenance phase of the proposed facilities, and would occur for the estimated 20-year life of the Project over the entire Project Area. For the entire Project Area, the operation and maintenance phase for any of the alternatives would occur concurrently with both the construction and installation phase, and the decommissioning/reclamation phase.
- Short-term increases in daily traffic were assessed for all the alternatives based on the daily travel of the average number of estimated workers for the decommissioning/reclamation phase of the proposed facilities, and would occur for approximately 10 years over the entire Project Area.
- Increases in average daily traffic counts would occur on the primary access roads into the Project Area, predominantly I-25, I-90, U.S. Highways 14 and 16, and State Highways 59 and 387.
- The additional traffic generated by the project-related vehicles was estimated based on the estimated average number of workers per day for Alternative 1 and for Alternative 3). The additional project-related traffic would be distributed throughout the entire Project Area.
- To compute the increases to average daily traffic count for the roads in the Project Area due to project-related vehicle trips for all of the alternatives, an average of 1.5 workers per vehicle was assumed for both the short-term construction and installation phase, and for the decommissioning/reclamation phase. One worker per vehicle was assumed for the operation and maintenance phase. Each worker was assumed to make one round trip per day.

- No new public roadways or new intersections would be built under any of the alternatives.
- A significant traffic volume impact would occur if the Project-related vehicle trips generate a 25 percent or more increase in the average daily traffic count compared to the existing (background) average daily traffic counts for the major access roads in the Project Area.
- An increase in accident rate is likely at intersections, or locations such as where a lane merges, if the increase in number of vehicles entering existing intersections is significantly higher than (10 percent of more) background conditions.

Alternative 1

Under the Proposed Action, approximately 6,657 and 10,619 miles of new improved and two-track roads would be associated with the new CBM facilities, respectively. Most of the roads to access well pads (resource roads) would be developed in two steps. Initially each road would be roughed in as a two-track road with an approximately 10 foot-wide rights-of way. Generally, the BLM requires improved graded and graveled roads with approximately 40 foot-wide rights-of way to conventional oil and gas operations. However, because the need to travel to the CBM wells is very limited, the BLM has waived the blanket requirements for road improvements to minimize surface disturbance. Road surfacing needs would be determined in consultation with the BLM or landowner based on site-specific conditions.

New access roads located on BLM or FS lands would meet BLM minimum road design and maintenance requirements, which are provided in BLM Manual Section 9113 – Roads (BLM 1985c) and the BLM Wyoming Supplement (BLM 1991). Road routes, locations, and design criteria are included in the APD and/or rights-of-way applications. The operators would provide the BLM with copies of all road maintenance agreements.

Unless work is needed to alleviate concerns about safety or access difficulties, the roads to access well pads would be maintained in a two-track status. Gravel may be applied to problem areas, such as stream drainage crossings, low water crossings, and areas of rough topography.

The counties and Companies would primarily be responsible for maintaining the Project’s improved roads in the Project Area. The counties would maintain the existing county roads and any roads covered by maintenance agreements with BLM. The Companies would maintain all other project roads.

In general, the Companies would reclaim access roads required for construction but not needed for production as soon as practical. If a well is not successful and is plugged, the road would be reclaimed. However, with the surface owners’ concurrence, the Companies could leave the road in place where there is value for ranching or agricultural uses. If a landowner decides to keep a road, then the landowner would accept responsibility for maintaining the road upon abandonment by the Companies.

Reclamation of access roads would be performed after production activities are completed. Access roads would be reclaimed by ripping/plowing and seeding unless the landowner and/or land manager wishes to make use of any roads and accepts responsibility through execution of a release for future road maintenance. Roads not needed for further work would be blocked, re-contoured, reclaimed, and reseeded/revegetated. Reclamation would be consistent with the requirements of the federal managers (according to Onshore Oil and Gas Order No. 1, Approval of Operations), and the State of Wyoming. On private lands, the Companies would execute release of the roads to the landowner or reclaim it according to the terms of the surface use agreements that may be in effect at that time.

All road disturbances on federal lands would be reseeded with a seed mixture approved by the Authorized Officer, as described in the APD Surface Use Program or Conditions of Approval. The seed mixture would be planted in the amounts specified in pounds of pure live seed per acre. All seed mixtures would be certified as weed free. Commercial seed would be either certified or registered seed. Seeding and/or planting would be repeated until satisfactory revegetation is accomplished.

For the Proposed Action, the average number of project-related workers per day would decrease from 1,043 workers during the initial short-term construction and installation period, to 395 workers per day during the long-term operation and maintenance period. Drilling, well installation, and completion for an individual well is anticipated to take approximately six days, requiring an average of 5 workers per day.

The average number of workers required for the decommissioning/reclamation phase for this alternative is estimated to be approximately 603 workers per day. During the decommissioning/reclamation phase, there would be short-term increases in traffic generated during the removal of equipment and reclamation at the individual well sites. Reclamation is estimated to require about three workers per day for five days per facility.

Transportation-related effects from implementation of the Proposed Action are summarized:

- The average daily traffic would increase by approximately 3,129 additional vehicle trips (based on estimated number of workers per day), distributed over the various roads within the entire Project Area for the short-term construction and installation phase of the Project.
- The average daily traffic would increase by approximately 790 additional vehicle trips (based on the estimated number of workers per day) for the long-term operation and maintenance phase of the Project, distributed over the various roads within the entire Project Area.
- The average daily traffic would increase by approximately 1,206 additional vehicle trips (based on the estimated number of workers per day) for the decommissioning/reclamation phase of Project, distributed over the various roads within the entire Project Area.
- Based on the proposed well locations, approximately 63 percent of the additional daily traffic due to project-related vehicles would occur within the

Upper Powder River and Upper Belle Fourche River sub-watersheds. Project-related traffic would be dispersed throughout these two sub-watersheds, and would result in a relatively large increase in traffic on state and local roads during the life of the Project, primarily affecting State Highways 59 and 387.

- Most of the remainder of the additional daily traffic due to project-related vehicles would occur in the Clear Creek, Crazy Woman Creek, Upper Tongue River, and Little Powder River sub-watersheds due to the relatively high numbers of proposed wells and facilities.
- The estimated increases to average daily traffic due to project-related vehicles is more than a 25 percent increase, compared to the existing average daily traffic counts for some of the roads in Project Area.
- The estimated increase in risk of traffic accidents due to additional the traffic of project-related vehicles, would be approximately the same percent increase as the percent increase in average daily traffic counts due to project-related vehicles, compared to the existing daily traffic counts for the roads in the Project Area.
- Relatively minor traffic delays, caused by short-term lane closures, would occur at some of the road crossings in the Project Area during the short-term project-related activities.

Alternatives 2A and 2B

For Alternatives 2A and 2B, the estimated employment requirements and anticipated trips per day would be approximately the same as those discussed for Alternative 1. The effects to transportation resources associated with the implementation of Alternatives 2A and 2B would be the same as those described for Alternative 1.

Alternative 3

Because fewer new wells would be drilled and fewer pads constructed, the number of average workers per day would be less than that under the Proposed Action. Assuming an average of 353 workers per day for the construction and installation phase associated with implementation of Alternative 3, the average daily traffic would increase in the short-term by approximately 1,059 additional vehicle trips (based on estimated number of workers per day), distributed over the various roads within the entire Project Area.

For Alternative 3, an estimated average number of 169 workers per day are required for the long-term operation and maintenance phase for the 20-year life of the Project throughout the entire Project Area. This results in long-term increase in the average daily traffic of approximately 507 additional vehicle trips, distributed over the various roads within the entire Project Area.

Approximately 230 additional project-related vehicle trips are estimated for the short-term decommissioning/reclamation phase of Alternative 3, distributed over the various roads within the entire Project Area.

The estimated increases to average daily traffic, due to project-related vehicles for the short-term construction and installation phase of Alternative 3, are an increase of more than 25 percent, compared to the existing average daily traffic counts for some of the roads in Project Area.

Cumulative Transportation Effects

Direct adverse effects to the primary access routes within the Project Area, including State, BLM, FS, and county roads, would occur due to project-related vehicular traffic associated with the implementation of any of the alternatives. The additional traffic is expected to increase the rate of degradation of the existing roadways in the Project Area, primarily in the Upper Powder River and Upper Belle Fourche River sub-watersheds.

Visual Resources

Development of coal bed methane in the Project Area would alter the physical setting and visual quality of the landscape, and affect the landscape as experienced from sensitive viewpoints, including travel routes and popular use areas. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture, which characterize the existing landscape. The landscape provides a scenic setting for recreational and residential uses of the area.

Direct effects to visual resources occur due to the disturbance of the landscape by project activities and the addition to the landscape of proposed facilities, including the well pads, pumping units, compressors, and associated electric power lines, pipelines, and access roads. Direct effects can be short or long term.

Short-term effects result from temporary disturbances to visual resources, including construction and installation activities. Short-term effects to the visual character of the landscape can result from construction of small temporary pits on drill sites, well drilling, and construction of ancillary facilities, such as access roads, pipelines, power lines, CMFs, and compression stations.

Long-term effects result from the addition of permanent structures to the landscape and from the operation of facilities. Long-term disturbance would result from the development of wells pads, CMFs, improved and two-track access roads, power lines, and compressor stations. Effects from long-term disturbance would occur over the expected 20-year life of the Project. The largest effects would occur from the addition to the landscape of wells and the disturbances resulting from the removal of vegetation on well pad areas and access roads. Each two-track well access road would connect with local roads that provide access into the Project Area. All gathering lines, water lines, high pressure gas lines, and underground electrical cables would be located along road ROWs wherever feasible, and would likely result in visual effects that exceed those of the access roads alone.

Alternative 1

Construction Disturbance

Short-term effects during the 10-year construction period to the visual character of the landscape at each well pad would result from well pad construction, well drilling, and associated construction of ancillary facilities, such as access roads, power lines, pipelines, and compressor stations. Construction and installation of pipelines would immediately follow construction of access roads and well pads and coincide with the completion of well drilling. Each well pad access road would connect with local roads that provide access in the Project Area. All gathering lines, water lines, high-pressure gas lines and power lines would be located adjacent to road ROWs. A summary of estimated short-term disturbance from each type of facility within each sub-watershed is estimated in Chapter 2.

The short-term disturbance associated with implementation of this alternative could disturb as many as 179,307 acres or approximately 2 percent of the Project Area. Most of the disturbance would occur on federal, state, and private lands inventoried with VRM Class IV. Most of the disturbance would result from the construction of pipelines and roads. Temporary disturbances would not conflict with VRM objectives because for each well pad and associated access road and power line, construction disturbances would occur over a period of less than two years, after which they would be reclaimed back to permanent disturbances associated with operations and maintenance. VRM objectives address modifications to the landscape from long-term facilities.

Drill site preparation, drilling, and well completion activities are generally short-term effects. Drilling would occur over a 10-year period throughout the Project Area. Drilling activities associated with individual wells would be short-term, typically occurring 24 hours per day for a one to three day period for each well. Drilling activities would occur at night, so that lighting on drill rigs would be visible from residences with a direct line-of-sight to well sites. During the construction period, these activities would detract from the visual quality of the landscape and potentially conflict with residential and recreational uses, because they would be visually and audibly intrusive to residents and visitors. However, construction activities would be spread over the 10-year construction phase. The visual intrusion of these activities would be site specific and would not affect viewers outside of the viewshed of each construction site in the Project Area. The effects to the existing landscape from drilling are site specific and would occur at specific locations for no more than three days per drill site throughout the 10-year drilling period. The total disturbance associated with construction activities would not all occur at the same time within the overall ten-year construction phase. Some sites would be reclaimed back to the permanent disturbance areas before construction at other sites.

Drilling activities would be accomplished using drilling rigs, water trucks, backhoes, graders, or dozers and well servicing equipment. During a period of one to three days, these activities would detract from the visual quality of the landscape at each drill location. Once each well is completed, all disturbed areas not needed for production facilities would be restored. The mud pit would be dried and backfilled. Seeding of these areas would take place as soon as practicable.

In addition to the disturbances created by construction on the sites, there would be traffic associated with moving equipment over public highways and local roads. Trucks would be used to transport drilling components, auxiliary components, and personnel to each well site.

Construction activities would be evident to people using roads within the Project Area. Residents and visitors in the Project Area would be impacted by the sight, dust, and noise of construction activities. In addition, the transport of equipment and materials to the Project Area would be evident to other travelers on local highways that would be used to access well sites.

Permanent Disturbance

The Proposed Action would constitute a change of the visual character of the existing rural landscape that characterizes most of the Project Area. The addition of well sites and associated access roads and power lines would result in a mixed rural/industrial landscape. The components with the highest potential to adversely affect the visual character of the area are the well pad clearings, pumping units, power lines, and access roads. The operation of the proposed facilities would introduce new elements of form, line, color, and texture into the landscape, and would essentially dominate foreground views and be obvious in middle ground and background views.

Long-term effects over the life of the Project would result from the addition of the wells to the landscape and the disturbance of lands used for associated facilities, such as power lines, water handling facilities, and compressor stations. The most visible components of the proposed facilities are expected to be the clearings for well pads and access roads, wellhead facilities, CMFs, water handling facilities, and compressor stations within the Project Area. CBM development is expected to modify the visual character of the existing rural landscape in the affected sub-watersheds that previously had little or no oil and gas development. Proposed activities would not change the rural/industrial character of the landscape near Gillette and along segments of Project Area highways, which currently includes considerable modification from other oil and gas activities and from coal mining.

Most existing oil and gas development exists in the Little Powder, Upper Belle Fourche, and Upper Powder River sub-watersheds in the general vicinity of Gillette. The landscape in this portion of the Project Area is characterized by oil and gas development occurring in 80 to 160 acre well spacing patterns. Additional CBM development in these three sub-watersheds would increase the areal extent of the industrial components of the rural/industrial landscape. However, the overall landscape character in this area would remain similar to the existing landscape.

Once well productivity is established, production facilities would include a weatherproof box structure placed over the wellhead and a metal fence or rail placed around the box and electrical panel to protect them from livestock. There would be no pump jacks or other facilities at the wellheads. The facilities would be painted in non-reflective colors that harmonize with the surrounding landscape. The well pads would be 0.1 to 0.3 acres in size, depending on the number of wells located on the pads. Production facilities would be visible primarily in the foreground distance zone of about 0.5 miles or less from any viewing area. In the foreground/middleground to background distance zones (or greater that 0.5 miles from a viewing area) the facilities would blend with the existing colors of the surrounding environment. The well pad clearings and access road disturbances would be visible in all zones due to contrasts in color and texture with the surrounding vegetation. The collocating of wells on a well pad minimizes the overall effect to the landscape by reducing the number of well pad clearings required for production facilities.

The largest effects would be to residential areas and isolated residences in the Upper Powder, Upper Belle Fourche, Clear Creek, Little Powder, Antelope, and Upper Tongue River sub-watersheds, particularly in those sub-watersheds in the general vicinity of Gillette. Several well pads with one or more wells would be adjacent to or within foreground distance zones of up to a mile from residences in some subdivisions located adjacent to Gillette municipal boundaries. Visible features would consist of well production facilities, well pad clearings, and access roads. Facilities would be most visible to travelers on affected highways during that period of time when they are within the line of sight as they travel towards the facility.

Approximately 10,619 miles of two-track roads and 6,657 miles of improved roads would be constructed to access proposed facilities from highways and local roads in the Project Area. Two-track roads would be used to access CBM wells in many cases because the need to travel to CBM wells is very limited. Two-track roads comprise a visible disturbance on the ground surface; however, as no surfacing is required, the visible disturbance from a two-track road is considerably less than the disturbance required for improved access roads. Improved roads would be constructed for some areas in rugged terrain and for non-CBM operations. Improved roads require a greater area of disturbance per mile of road and provide a greater degree of contrast between the road and the surrounding vegetation than two-track roads. Access roads would be visible primarily in the foreground zones. The visual impact of each road can be lessened by aligning the road with the contours of the topography instead of cutting across the contours to the well pad, particularly on slopes. However, this method of aligning the roads may result in a greater area of disturbance. All roads constructed for the Project would be removed and reclaimed, unless specifically requested by the landowner or county.

The gas-gathering and water-gathering pipelines would be buried adjacent to existing and new road ROWs. The combined ROW of each road and pipeline would vary according to the type of pipeline installed along the road. Installation of the pipeline would avoid trees, where practicable, and brush and woody vegetation would be left in-place and driven over so that it is potentially capable of redeveloping a vegetative canopy. Reclamation would begin immediately after burying the pipeline. There would be no long-term effects to the landscape once pipelines are installed and reclaimed.

Aboveground electric distribution lines would connect wells and compressor stations with the existing transmission and distribution system within the Project Area. Electricity would be routed to facilities along the access roads or on additional ROWs (30 feet wide) across open land. Construction of power lines would follow access road development and coincide within the completion of well drilling. Power lines typically would be installed on 35-foot poles, which would be required approximately every 300 feet. Approximately 5,311 miles of aboveground power lines would be installed in the Project Area. The pole structures would introduce straight, vertical lines and color contrasts. The effects from the introduction of these elements into the landscape can be noticeable when viewed from sensitive viewpoints when structures are visible in scenic landscapes and when structures are skylined.

Each compressor station would be lit at night with 250-watt, clear lamp lights. Each light would be mounted on a pole or building and directed downward to illuminate the facility while minimizing the amount of light projected outside the facility. This type of night lighting would minimize the night shine from each facility. However, the stations would be visible at night to residents in nearby residential areas, isolated residences, or travelers on highways and local roads.

Produced water from CBM wells would be discharged by five methods: surface discharge at outfalls, containment in large upland evaporation reservoirs, spread on the land surface at LAD sites, or injected at an injection well facility site. The proposed water handling methods would disturb a total of 32,685 acres of surface land. Nearly half of the disturbance would occur from infiltration impoundments (45 percent). Water disposal at infiltration impoundments, containment reservoirs or LADs would result in modifications to the surrounding landscape at the disposal sites. Surface discharge in some areas may cause a red surface staining from iron oxidation where water is retained at the discharge point long enough for oxidation to occur before surface discharge. The impact to the landscape would be limited in areas where these conditions would occur.

Each infiltration impoundment would consist of a shallow impoundment that would encompass an average of 6 acres, with an average dam height of 13 feet. Impoundments would be located in upland and bottomland areas. A total of 14,566 acres would be disturbed by infiltration impoundments, primarily in the Upper Powder River, Upper Cheyenne River, Crazy Woman Creek, and Upper Tongue River sub-watersheds. The majority of these areas are inventoried with VRM Class IV. The sites would have a low profile and would not be easily visible in the middleground and background zones from viewpoints at similar or lower elevations. The average 13-foot height of the dams would be the most visible feature of the impoundments, as the top of each dam would appear as a horizontal, linear form that would contrast with the natural terrain. Evaporation atomizers would be placed on towers that are likely not more than 40 feet in height, and would appear as a weak vertical contrast with the surrounding terrain. The spray from atomizers would be visible in foreground distance zones, but would be indistinct in middle ground to background zones. Infiltration impoundments would be obvious in the foreground zone as seen from nearby roads and residences. Setting the impoundments back from roads, leaving a buffer zone of topography and vegetation, would mitigate the visual intrusion

LAD sites would contain all water discharged over the life of 40 wells, affecting 1,780 acres of land surface (5.4 percent of total acres disturbed by water handling methods) in the Project Area. Each LAD site would be comprised of four 16-acre LAD areas. The LAD sites would be located in relatively flat terrain to minimize off-site drainage and earth-moving activities. The sites would have a low profile and would not be easily visible in the middleground and background zones from viewpoints at similar or lower elevations. The evaporation atomizers placed on towers would constitute a weak linear visual intrusion. LAD sites would be obvious in the foreground zone as seen from nearby roads and residences. Setting the LAD sites back from roads, leaving a buffer zone of topography and vegetation, can mitigate the visual intrusion. LAD sites would be located near containment reservoirs, which would provide temporary storage for those time periods that the LAD site is not operational. In addition, the reservoirs would store water meant for LAD applications. The water disposed of at LAD sites is of a quality not suitable for surface discharge. Land application of this water would result in modifications to the existing vegetation, providing some contrast with existing vegetation.

The proposed containment reservoirs would affect approximately 2,247 acres. The average disturbed area for each reservoir would be 100 acres. The disturbed area is comprised of the surface area of each reservoir, the dam, and diversion ditches. Reservoirs would be constructed in upland areas, away from drainages, floodplains, and gravelly terraces. These areas are generally outside of the viewsheds of most transportation routes and communities in the Project Area. In general, the upland locations of reservoirs could result in additional disturbances from earth-moving activities and extensive diversion ditches. Those LAD sites that would be located near reservoirs in upland areas would also require more earth-moving activity than those located in flatter terrain, resulting in greater disturbances to the character of the landscape.

BLM Lands

A total of 5,613 CBM wells distributed on 3,461 well pads are proposed for BLM surface ownership in the Project Area, accounting for 14.3 percent of the 39,367 new CBM wells proposed for the Project Area. The BLM has inventoried all lands within the Project Area with the VRM system. However, only lands administered by the BLM are managed with VRM objectives. Although proposed CBM wells on state, private, and Forest Service lands are not managed for BLM's VRM objectives, the inventory provides an assessment of the existing scenic quality and the ability of these lands to absorb effects to the landscape from development activities.

Table 4–97 summarizes all proposed CBM wells in the Project Area proposed for Alternative 1 by sub-watershed and VRM Class inventory. The disturbance acres for well pads include the disturbance associated with ancillary facilities connected to the pads, such as roads, pipelines, and power lines. Water handling facilities, such as LADs and containment reservoirs, may be located on BLM lands, but specific locations by VRM Class are unknown.

There are 4,530 wells and 35 compressors proposed for BLM lands managed with VRM Class IV objectives. Most of the remaining wells and compressors are located on private lands and a small number are on state and Forest System lands. Lands inventoried with VRM Class IV account for most lands within the Project Area. Most CBM wells proposed for these lands are within the Upper Powder River sub-watershed. Class IV objectives provide for major modification to the landscape and allow management activities to dominate the landscape. The construction and operation of each well and the ancillary facilities would be consistent with VRM Class IV objectives. Consequently, none of the disturbed acreage would be displaced from the existing BLM inventory of lands managed with VRM Class IV. The proposed facility developments would be consistent with management objectives.

There are 3,939 wells distributed on 417 well pads and three compressor stations proposed for BLM lands managed with VRM Class III objectives. Class III lands in the Project Area are located primarily along major transportation routes and recreation areas. Class III objectives are to provide for management activities that may contrast with the basic landscape elements, but remain subordinate to the existing landscape character. Implementation of this alternative along highways and in areas not currently developed with CBM wells would change the existing rural landscape to a rural/industrial landscape primarily because the 40- to 80-acre spacing of the wells would result in a noticeable density of industrial facilities. There is potential that Class III objectives would not be met because the facilities would not be subordinate to the existing landscape character. BLM objectives for some Class III facilities would be met if every attempt were made to minimize adverse visual effects through careful location of facilities, minimal disturbance of the site, and painting of facilities so they harmonize with the colors of the surrounding landscape.

Table 4–97 Proposed Wells and Well Pads in VRM Classes by Sub-watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
Sub-Watershed	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Total Proposed Wells	Total Proposed Pads	Long Term Pad Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	163	54	124	358	192	439	2,068	892	2,040	0	0	0	2,589	1,138	2,602
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	782	448	7,157	2,634	1,461	23,339	15,551	9,933	158,676	0	0	0	18,967	11,842	189,171
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	37	37	14.3	0	0	0	37	37	14.3
Crazy Woman Creek	0	0	0	414	397	1,437	2,506	1,500	5,429	0	0	0	2,920	1,897	6,866
Clear Creek	187	185	736	907	540	2,150	2,659	1,861	7,409	0	0	0	3,753	2,586	10,296
Middle Powder River	0	0	0	0	0	0	958	465	384.6	0	0	0	958	465	385
Little Powder River	0	0	0	25	18	84	1,810	1,077	5,000	200	170	790	2,035	1,265	5,873
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	91	83	1,342	1,553	1,368	22,117	0	0	0	1,644	1,451	23,459
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	487	487	355	46	46	34	533	533	388
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	752	644	5,084	5,046	4,005	31,617	133	134	1,058	5,931	4,783	37,759
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,132	687	8,017	5,181	3,335	33,874	32,675	21,625	23,3042	379	350	1,881	39,367	25,997	276,813

Note: Disturbance acres for well pads include the disturbance associated with ancillary facilities such as roads, compressors, and transmission lines. Totals may not match precisely with values obtained by adding unit numbers or with distributions of pads and wells presented in Chapter 2 due to rounding conventions.

There are 317 wells and two compressor stations proposed for BLM lands managed with VRM Class II objectives. None of these wells would be in the Class II lands in the western part of the Project Area at the base of the Big Horn Mountain. All 317 wells would be within the Class II areas along portions of Interstate 90 and State Highway 14.

The VRM Class II objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low and not attract the attention of the casual observer. Many of the CBM wells on BLM lands would be visible to travelers on Interstate 90 and State Highway 14. All of the wells proposed for these areas are within the foreground distance zone (up to three miles) of the viewshed as seen from the highways. The Proposed Action would change the existing rural landscape to a rural/industrial landscape primarily because the 40- to 80-acre spacing of the wells would result in a noticeable density of industrial facilities. The Class II objectives would be met if mitigation measures were used to maintain the existing character of the landscape, and not attract the attention of the casual observer. In order to achieve this objective, mitigation must repeat the basic elements of form, line, color, and texture found in the natural features of the landscape within the foreground distance zone. Successful mitigation in the foreground distance zone would include locating facilities to utilize the terrain and vegetation to screen them from the highways. If the implementation of mitigation measures would not enable facilities to meet Class II objectives, one of the following two options must be implemented to comply with BLM management objectives: 1) the facilities would be relocated to a site outside of the VRM Class II area on BLM lands; and 2) the BLM RMP would be amended to change the affected VRM Class II areas to VRM Class III areas.

There are three CBM wells and one compressor station proposed for BLM lands inventoried with VRM Class V. The proposed facilities on BLM lands would be consistent with BLM management objectives for VRM Class V areas, which provide for areas where the natural character has been drastically altered.

The Buffalo Field Office has developed a management decision to implement the management objective of maintaining or improving scenic values, visual quality, and establish visual resource management priorities in conjunction with other resource values. Visual resources are to be managed in accordance with objectives for VRM classes that have been assigned to the planning area, which constitutes most of the Project Area. No activity or occupancy is allowed within 200 feet of the edge of state and federal highways. Facilities or structures such as power lines, oil wells, and storage tanks are required to be screened, painted, and designed to blend with the surrounding landscape except where safety indicates otherwise. Any facilities or structures proposed in or near WSAs would be designed so as not to impair wilderness suitability.

BLM lands in the Fortification Creek WSA and the Fortification Creek SMA are inventoried with VRM Class III. The WSA has an NSO for mineral development. The Fortification Creek SMA, which encompasses the WSA, has a CSU stipulation to protect scenic values. Proposed facilities in the SMA must meet Class III objectives to protect scenic values. There is potential that Class III objectives would not be met because the facilities would not be subordinate to the existing landscape character. BLM objectives for some Class III facilities would be met if every attempt were made to minimize adverse visual effects through careful location of facilities, minimal disturbance of the site, and painting of facilities so they harmonize with the colors of the surrounding landscape. No facilities are proposed for the WSA because of the NSO, however, to ensure the scenic integrity of the WSA, a buffer that excludes any CBM development should separate the WSA from the surrounding SMA.

The Cantonment Reno and Weston Hills Recreation Area are inventoried with VRM Class IV. No project facilities are proposed for location within these two SMAs. Indirect effects to recreational uses of the SMAs would occur because landscapes outside of these areas would be modified by the addition of project facilities, which would affect the recreational experience of visitors to the SMAs. CBM wells proposed for lands adjacent to the Cantonment Reno and Weston Hill Recreation Area would be visible to viewers in the areas. BLM Class IV objectives for the SMAs and adjacent lands would be met.

Long-term visual effects would be minimized by designing permanent structures to harmonize with the surrounding landscape to the extent feasible, recontouring and revegetating disturbed areas no longer needed for operations as soon as practicable, and by reshaping straight edges of clearings resulting from roads, pipelines, well pads, and compression facilities to create irregular or indistinct edges. Construction debris would be removed immediately because it creates undesirable textural contrasts with the landscape. In addition, resource protection measures proposed for erosion control, road construction, rehabilitation and revegetation, and wildlife protection would be implemented during the approval of APDs and Sundry Notices. These measures also would mitigate effects to visual quality.

Forest Service (Thunder Basin National Grassland)

There are 437 wells distributed on 397 well pads proposed for federal lands administered by the Medicine Bow National Forest within the Thunder Basin National Grassland. Most of the federal lands on that portion of the TBNG that is within the Project Area are managed with the SIO of Low. A small portion of the TBNG within the Project Area is managed with the SIO of Moderate. The TBNG lands managed with Moderate SIO are along Antelope Creek or are in an area outside of the coal boundary. No wells are proposed for TBNG lands managed with the SIO of Moderate. All of the proposed 437 wells are on TBNG lands managed with the Low SIO.

Scenery Management guidelines for the TBNG are to manage activities to be consistent with the SIOs and to rehabilitate areas that do not meet the SIOs specified for the management area. Visual management objectives for SIOs are associated with desired landscape character for each management area and are based on the intent of the management area direction. Facilities are proposed for three of the seven management areas within the Project Area. Management Areas 3.68 (Big Game Range) and 6.1 (Rangeland with Broad Resource Emphasis) on which facilities are not managed with goals for a desired condition for scenic values. The SIO for these areas is Low. Few facilities are proposed for these areas. The majority of wells and ancillary facilities are proposed for Management Area 8.4 (Mineral Production and Development). The desired condition for landscapes in this management area is that facilities and landscape modifications can be visible, but are reasonably mitigated to blend and harmonize with natural features.

State and Private Lands

There are 2,744 wells distributed on 1,739 well pads and 14 compressor stations proposed for State lands in the Project Area. Mineral leases administered by the Wyoming Office of State Lands and Investments do not include guidance on the management of visual or scenic resources on state-owned lands in the Project Area. According to rules and regulations of the Board of Land Commissioners, upon completion of operations on state lands, all related disturbances on state lands must be reclaimed to leave the land in as near as practicable to the original condition of the land before operations.

Most of the proposed facilities would be located on private lands. There are 30,573 wells (77.8 percent of total proposed wells) distributed on 20,400 well pads (78.5 percent of proposed well pads) and 126 compressor stations (68 percent of total number of compressor stations) proposed for private lands in the Project Area. The majority of effects to the landscape would occur on private land because most wells are located on private land and most of the land within the viewsheds of communities, rural residential areas, and transportation routes is private land.

Counties

The Sheridan County Growth Management Plan identifies the need for an inventory of existing resources, including scenic resources, and the utilization of this information in the review and evaluation of proposed developments. Currently no procedure or ordinance exists that provides for evaluation and review.

The Comprehensive Planning Program jointly developed by the City of Gillette and Campbell County recommends that landscaping should be developed into the buffer zones where industrial areas are located adjacent to residential areas. There are numerous CBM wells proposed for lands adjacent to residential areas in subdivisions located outside of the Gillette municipal boundaries.

Non-CBM Development

The moderate level of conventional oil and gas development as evaluated under the BLM’s RFD scenario projects the drilling and completion of 3,000 non-CBM wells within the Buffalo Field Office’s portion of the Project Area over the 10-year period. Surface disturbances required for conventional wells are greater than those required for the new CBM wells as described earlier in this section. Short-term surface disturbances for well pads and associated improved access roads range from 0.5 acres for shallow gas wells to 5.5 acres for a typical deep oil well. Long-term disturbances would encompass about 82 percent of the original disturbance.

Non-CBM facilities consist of pump jacks, in contrast with CBM facilities, which consist of a wellhead contained in a metal box. The components with the highest potential to adversely affect the surrounding landscape character are the well pad clearings, the improved access roads, and the pump jacks. The operation of the proposed facilities would introduce new elements of form, line, color, and texture into the landscape; would essentially dominate foreground views; and would be obvious in middleground and background views. Effects would be similar to those described for CBM well facilities; however, each well pad and associated access road would disturb a larger number of acres.

The alignment of individual pump jacks with respect to viewing areas, such as residential areas, individual residences, and transportation routes, should be reviewed during the pre-installation phase of well development. In general, each pump jack should be aligned parallel to a road unless it has been determined that this type of alignment is not feasible. Facilities would be the most visible to travelers on the road during that period of time when the facility is within the line of sight as they travel towards the facility. Aligning pump jacks parallel to roads would present travelers with a smaller surface area as the traveler approaches the facility. In addition, pump jacks with the lowest possible profile should be used when feasible.

Alternative 2

Alternative 2 differs from Alternative 1 in the distribution of produced water among the methods for handling produced water, and the compression of gas. Alternative 2A emphasizes the use of infiltration impoundments to dispose of produced water, while Alternative 2B emphasizes the use of passive and active treatments. The number and distribution of CBM and non-CBM conventional wells is the same as evaluated for the Alternative 1. The impacts to the characteristic landscape from the development of CBM well and the ancillary facilities other than facilities for handling produced water is identical to those described for the Alternative 1.

Alternative 2A or Alternative 2B would result in the disturbance of more surface acres (39,367 acres) than Alternative 1 or Alternative 3. For both Alternatives 2A and 2B, the largest disturbances would occur from infiltration impoundments (32,253 acres under Alternative 2A and 23,446 acres under Alternative 2B). The operation of infiltration impoundments under Alternative 2A would affect 121 percent more surface land that impoundments proposed for Alternative 1. Alternative 2B would affect 61 percent more surface land that Alternative 1. The impact to the visual quality of the landscape is substantially larger from Alternatives 2A or 2B than for the proposed Alternative 1. The impoundments would be located outside of transportation corridor and residential area viewsheds, and would primarily affect lands inventoried with VRM Class IV.

Under Alternatives 2A and 2B, LAD sites would affect 6,296 acres of land in the Project Area, an increase of 254 percent over the LAD sites proposed for the Proposed Action. The containment reservoirs would affect approximately 2,583 acres under Alternative 2A or 2,148 acres under Alternative 2B. Alternative 2A would be an increase of 14.9 percent over the Proposed Action, primarily within VRM Class IV areas. Alternative 2B would be a decrease of four percent from the Proposed Action. The large increase in LAD sites over the Proposed Action would result in larger areas of modified vegetation as described for the Proposed Action. The number of acres disturbed by containment reservoirs would not be substantially different from the Proposed Action, and would result in a similar level of visual impact. The effects of injection wells and surface discharge to the landscape would be minor. A total of 39,367 acres would be affected from these water-handling methods proposed for Alternative 2A or Alternative 2B, which is more than 20 percent greater than the total 32,685 acres that would be affected under the Proposed Action.

Alternative 3

Under the No Action alternative, there would be no CBM development on federal leases within the Project Area. Federal leases are located on private as well as federal lands. Development would continue on State and private leases. A total of 15,458 CBM wells would be developed on State and fee leases. The No Action alternative includes all of the effects to visual resources described for Alternative 1, but differs from Alternative 1 in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the Project, and the volume of water to be produced from CBM wells. The effects to the characteristic landscape from the No Action alternative would considerably less than those described for the Proposed Action because 15,458 CBM wells proposed for State and fee mineral leases is approximately 39 percent of the total 39,367 new CBM wells under the Proposed Action. Table 4–98 summarizes the long-term disturbance by VRM Class for each sub-watershed. Although proposed CBM wells on state and fee lands are not managed for BLM's VRM objectives, the inventory provides an assessment of the existing scenic quality and the ability of these lands to absorb effects to the landscape from development activities.

Because there are fewer wells proposed for the Project Area, there would also be a considerably smaller number of facilities proposed for the distribution of produced water under the No Action alternative. LAD sites would affect 808 acres of land in the Project Area, a decrease of 55 percent from the LAD sites proposed for the Alternative 1. The containment reservoirs would affect approximately 2,159 acres, a decrease of 58 percent from the Alternative 1. The effects of injection wells and surface discharge to the landscape would be minor. A total of 15,458 acres would be affected from all water-handling methods proposed for this alternative, which is about 83 percent less than the total 32,685 acres that would be affected under the Alternative 1.

Cumulative Effects

The cumulative well development scenario is comprised of the 39,367 wells under the Proposed Action and 12,077 CBM well already drilled or permitted within the Project Area. Table 4–99 summarizes the long-term disturbance by VRM Class for each sub-watershed.

Table 4–98 Alternative 3 Wells and Well Pads in VRM Classes by Sub-Watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
Sub-watershed	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Total Proposed Wells	Total Proposed Pads	Long Term Pad Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	130	44	101	345	189	432	1,683	740	1,692	0	0	0	2,158	973	2,225
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	146	93	1486	661	390	6230	3,629	2,356	37,636	0	0	0	4,436	2,839	45,352
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	19	19	7	0	0	0	19	19	7
Crazy Woman Creek	0	0	0	183	183	662	751	446	1,614	0	0	0	934	629	2,277
Clear Creek	120	114	453.9	841	506	2015	1,527	1,120	4,459	0	0	0	2,488	1,740	6,928
Middle Powder River	0	0	0	0	0	0	201	97	80	0	0	0	201	97	80
Little Powder River	0	0	0	14	9	41.8	800	509	2,363	145	134	622	959	652	3,027
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	40	32	517	563	494	7,987	0	0	0	603	526	8,504
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	236	236	172	24	24	17	260	260	189
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	574	502	3963	2,705	2184	17,241	121	121	955	3,400	2,807	22,160
Middle North Platte Casper	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	396	251	2,040	2,658	1,811	13,862	12,114	8,201	73,251	290	279	1,595	15,458	10,542	90,748

Note: Disturbance acres for well pads include the disturbance associated with ancillary facilities such as roads, compressors, and transmission lines. Totals may not match precisely with values obtained by adding unit numbers or with distributions of pads and wells presented in Chapter 2 due to rounding conventions.

Table 4–99 Cumulative and Well Pads in VRM Classes by Sub-Watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
Sub-watershed	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Proposed CBM Wells	Proposed Pads	Long Term Pad Disturbance (acres)	Total Proposed Wells	Total Proposed Pads	Long Term Pad Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	486	190	434	444	247	565	2,474	1,098	2,511	0	0	0	3,404	1,535	3,510
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	964	581	9,282	2,831	1,623	25,927	17,980	11,891	189,954	0	0	0	21,775	14,095	225,162
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	37	37	14	0	0	0	37	37	14
Crazy Woman Creek	0	0	0	540	443	1,604	2,530	1,518	5,495	0	0	0	3,070	1,961	7,098
Clear Creek	199	192	764	1,141	678	2,700	2,802	1,943	7,736	0	0	0	4,142	2,813	11,199
Middle Powder River	0	0	0	0	0	0	1,685	899	744	0	0	0	1,685	899	744
Little Powder River	0	0	0	37	31	144	3,373	2,175	10,098	438	360	1,672	3,848	2,566	11,913
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	92	84	1,358	1,805	1,618	26,159	0	0	0	1,897	1,702	27,517
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	920	860	626	67	62	45	987	922	671
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	1,261	1,134	8,952	9,160	7,749	61,174	172	170	1,342	10,593	9,053	71,468
Middle North Platte Casper	0	0	0	0	0	0	6	0	0	0	6	1	6	6	1
Total	1,649	963	10,480	6,346	4,240	41,249	42,772	29,788	304,509	677	598	3,060	51,444	35,589	359,298

Note: Disturbance acres for well pads include the disturbance associated with ancillary facilities such as roads, compressors, and transmission lines. Totals may not match precisely with values obtained by adding unit numbers or with distributions of pads and wells presented in Chapter 2 due to rounding conventions.

The cumulative effect on the landscape would consist of existing, permitted, and proposed CBM development on federal, State and private lands in the Project Area, and existing, proposed, and reasonably foreseeable coal mining in the Project Area. The cumulative effect of all existing and proposed development would result in a larger number of disturbed acres from well pads and access roads that may be visible from transportation routes and recreation areas. Ongoing CBM development on federal, State, and private lands would increase the industrial character of those areas that include considerable modification from other oil and gas activities and from coal mining, and change the visual character of the predominantly rural landscape in much of the Project Area to rural/industrial.

A principal visual effect in the eastern part of the Project Area and near the city of Sheridan is the visibility of coalmine pits and facility areas. However, anyone likely to see these facilities would either be passing through the area or visiting on related business. After mining, the reclaimed slopes might appear somewhat smoother than pre-mining slopes and there would be fewer gullies than at present. Even so, the landscape of the reclaimed mines would look very much like undisturbed landscape in the area. Except from the air, energy development activities, including CBM development, are not visible from more than a few miles away.

Recreational Resources

The potential effect of the construction and operation of the proposed facilities on recreational resources is related to how much recreational opportunity is being created by the Project versus how much opportunity is being lost for recreational pursuits. Local residents value the federal lands for recreational activities because of the proximity to their homes and the relative solitude that can be achieved within a short distance from their homes. The recreational issue identified in the scoping process is the effects of the additional development of oil and gas resources on recreational opportunities and the recreational experience.

Alternative 1

The Proposed Action would be constructed and operated on federal, State, and private lands. The primary effect of the CBM development on recreational opportunities would be the alteration of the recreational experience on federal and State lands used for hunting. To some degree, additional development of oil and gas resources would alter the existing recreational setting and experience. The Project Area is predominantly rural in character with some industrial-type modifications from existing wells.

Direct effects to recreation occur when recreational opportunities are enhanced, limited, or curtailed within an area; when recreational uses are created, displaced, or eliminated by proposed CBM facilities; or if federal, state, or county objectives for recreation cannot be met. Effects to recreational resources occur if recreational facilities undergo substantial change or degradation.

Direct effects to recreational uses in the Project Area would occur because additional wells would add new industrial features to the landscape and new sources of noise that could diminish the recreational experience and affect the rural ambience sought by recreationists. The construction and operation of the proposed facilities also could affect recreational activities by changing access opportunities and by directly disrupting recreational activities. New roads would provide access for vehicles and promote an increase in human activity. Additional development could adversely affect hunting, viewing of wildlife, and fishing. Development of certain facilities, such as reservoirs for impounding produced water, could enhance some wildlife-related recreational opportunities by providing areas for viewing wildlife, hunting waterfowl, or public fishing.

Indirect effects to recreation would occur if the Project resulted in a change in the level of visitation to the area or if the Project would affect growth in the affected counties, thereby changing the utilization of existing recreational facilities and uses. No developed recreation sites would be impacted by the Proposed Action. Therefore, visitation to these sites would not be affected by the Proposed Action. Hunting may be affected in some game management units. The Project is not expected to affect the level of visitation and population growth in the counties. It is anticipated that the existing workforce would be sufficient to provide adequate personnel for the construction and operation of proposed CBM facilities; therefore, there would be no growth in population from in-migration and no increase in the demand for recreation opportunities.

Construction Disturbance

Short-term effects to recreation within the Project Area would result from all phases of the construction process. Activities associated with the installation of the proposed wells, including construction of roads, pipelines, power lines, and other ancillary facilities, would alter the use of affected roads for the duration of construction activities. Construction activities can be expected to occur over a period of 10 years over the entire Project Area. It is anticipated that the annual construction period would be seven days per week over the entire year, or 365 days, depending on weather and soil conditions. During this period, there would be disturbance to the existing landscape character, and noise and dust from construction activities. These activities would potentially conflict with recreational uses because they would be visually and audibly apparent to the recreational experience. The effects to the existing land uses from drilling are site specific and would occur at specific locations for no more than three days per drill site throughout the 10-year drilling period. Some sites would be reclaimed back to the permanent disturbance areas prior to construction at other sites.

In addition to the disturbances created by construction on the site, there would be traffic associated with moving equipment over public highways and local roads. Traffic-related effects are evaluated in the Transportation section. Access roads would be constructed to connect CBM facilities with highways and local roads. A total of 17,276 miles of improved roads and two-track roads would be constructed in the Project Area. Road construction is expected to average one day per mile, or a total of approximately 17,276 days. The construction would occur over the ten-year period as required to access wells. Recreationists would encounter road construction over the entire year at specific locations within the Project Area. The loss of solitude and the natural experience would affect local users in the particular area of construction.

Pipeline installation along existing road rights-of-way is likely to inconvenience recreationists who use the roads to gain access to recreational activities in the area. Construction activities would also limit recreational use of existing roads and trails, as well as degrade the visual quality of the recreational experience. The loss of solitude along these roads would continue through the construction period. Road access is likely to be restored to existing uses within a few days to a few months, once construction or installation activities have been completed. The recreational opportunities for local residents in close proximity to proposed activities would be altered during the construction period.

Project construction would result in increased noise levels from heavy equipment in surrounding areas. Construction-related noise could reduce the quality of the recreational experience in general. However, construction-related increases would be short-term and with the exception of blasting, generally restricted to the immediate vicinity of the work. Noise from blasting would be sporadic and of short duration. There are potential long-term increases in noise levels from the operation of the compressors.

The general season dates for big game hunting (all types of big game in all units) occur from late September/early October through late November. The hunting season would be affected by construction activities for the ten-year construction period, but only at specific locations where construction activities are scheduled.

Permanent Disturbance

Long-term effects to developed and dispersed recreational uses of the Project Area would occur as the displacement of acreage from existing uses by proposed CBM facilities. The primary effects would be an alteration of the recreational experience for residents and visitors to the Project Area. Recreational activities displaced by project facilities are likely to add increased use on adjacent federal and State lands.

Dispersed Recreation

Dispersed recreational opportunities in the affected counties include hunting, fishing, sightseeing, and camping. Dispersed recreation, with the exception of hunting, is not a primary use of most federal, State or private lands that are within the coal boundary of the Project Area. There is expected to be little change in existing levels of dispersed recreational activities on federal and State lands in most of the sub-watersheds within the Project Area as a result of CBM development under the Proposed Action. Existing levels of recreational activity are expected to continue on these lands. Most of the proposed activity would occur in the Upper Powder River, Little Powder, and Upper Belle Fourche sub-watersheds.

Hunting is the principal recreational activity on federal, State, and private lands in the Project Area. The acreage removed from wildlife habitat by project facilities under the Proposed Action is not likely to adversely affect hunting and fishing opportunities within the Project Area. Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally within the Project Area, as populations of game animals and game fish rise locally during the life of the Project, in response to increased availability of surface water and forage. However, increased access and human activity associated with CBM development may adversely affect wildlife populations that support various recreational activities.

Big game populations in big game management units west of I-25 and in other units outside of the coal boundary would not be affected by Project activities. Units that would be affected contain portions of one or more sub-watersheds with proposed CBM development. The largest effects to hunting would occur in the Upper Powder, Upper Belle Fourche, Little Powder, Clear Creek, Antelope, and Crazy Woman Creek sub-watersheds because most CBM development would occur in these sub-watersheds. These sub-watersheds contain portions of ten antelope game units (56 percent of total antelope game units in the Project Area), ten deer game units (45 percent of total deer game units), and two elk game units (22 percent of total elk game units). Table 4–100 summarizes the number of participating hunters, total hunter days, and non-resident hunters for the big game management units that would be affected by the proposed CBM development in the Project Area. A total of 12,866 active hunters or nearly 47 percent of the total estimated 27,491 active hunters in the Project Area potentially would be affected by the removal of wildlife habitat and the intrusion of project-related noise, dust, and visual effects from the proposed CBM development in addition to positive effects related to increased access and the potential rise in game and fish populations.

Table 4–100 Big Game Hunting in the Powder River Basin Project Area, 2000

Game Unit	Active Hunters	Total Harvest	Hunter Success (percent)	Hunter Days	Non-Resident Hunters	Percent Non-Resident Hunters
Antelope	4,292	3,907	91.0	10,512	3,276	76.3
Deer	8,347	5,158	61.8	27,695	4,449	53.3
Elk	227	152	67.0	715	31	13.7

Source: Wyoming Game and Fish Department, 2001

The development of roads and well facilities would result in greater physical access to the Project Area and potentially increase hunting pressures on wildlife. However, a majority of this access would be not be available to the public because much of the surface within the Project Area is privately owned.

Several streams and lakes in the Project Area are used for year-round fishing by local recreationists. All affected fishing areas are within sub-watersheds that would be developed with proposed CBM facilities. Effects to fish and their habitats are evaluated in the Wildlife section.

The operators have stated they would work with landowners in the Project Area to enhance the use of the good quality, discharged water. This practice may promote the impoundment of discharged water and use for wetlands and/or fisheries development. Given the potential quality of discharged water associated with the Project in some sub-watersheds, it is reasonable to conclude that enhanced vegetation and increased water availability probably would have some beneficial effects on fish and wildlife and their habitats and may enhance recreational opportunities in the immediate vicinity of any reservoirs created. This would continue until water production ceases. Water handling facilities would be constructed in sub-watersheds with low water quality for produced water in order to prevent potentially adverse effects on surface water and fish habitat.

Produced water from CBM wells would be discharged by four methods: surface discharge at outfalls, containment in large upland evaporation reservoirs, spread on the land surface at LAD sites, or injected at an injection well. Effects to recreation from the proposed 323 injection wells would be similar to those described for CBM production well facilities. About 27 LAD sites occupying 1,728 acres would result in large areas of modified vegetation. Development of LAD sites would potentially have an adverse effect on wildlife, and consequently, hunting opportunities in the affected sub-watersheds because the modified vegetation may affect the quality of the wildlife habitats. There are 142 containment reservoirs occupying 19,880 acres proposed for upland areas. Containment reservoirs would create opportunities for some wildlife-related recreational opportunities by providing areas for viewing wildlife, hunting waterfowl, or public fishing. The recreational experience also would be affected by the visual impact of the proposed water handling facilities.

Developed Recreation Areas and Recreation Sites

There are no CBM facilities proposed for developed recreational areas or recreational sites in the Project Area. Most of the developed recreational areas identified in Chapter 3 are located in the western part of the Project Area outside the coal boundary. Special management areas that are on federal lands administered by the BLM are discussed in the section evaluating effects to BLM management of federal lands in the Project Area.

BLM Recreation Management

Some federal lands administered by the BLM in the Project Area that include developed recreational sites or recreational activities have specific resource values that put them under No Surface Occupancy (NSO) mitigation guidelines. Lands managed with NSO include Recreation Areas, such as campgrounds, historic trail, and national monuments, and special management areas, such as areas suitable for consideration for wild and scenic rivers designation.

The BLM administers federal lands in the Middle Fork Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave Recreation Site (or Cultural Area), Dull Knife Battlefield site, and the Gardner Mountain and North Fork Wilderness Study Areas. There would be no effects to recreational uses of these special management areas because they are located ten miles or more outside of the coal boundary in the Middle Fork Powder Watershed. With the exception of the Middle Fork Recreation Area, these areas have NSO leasing stipulations for mineral development. There would be no effects to the landscape within or near these areas.

The Fortification Creek WSA and the Cantonment Reno, located in the Upper Powder River sub-watershed, each have NSO for mineral development. The Weston Hills Recreation Area, located in the Little Powder sub-watershed north of Gillette, does not have any NOS leasing stipulation. However, no project facilities are proposed for location within the Recreation Area. Indirect effects to recreational uses would occur as landscapes outside of the areas would be modified by the addition of project facilities and would affect the recreational experience of visitors to these areas. CBM wells are proposed for lands adjacent to Fortification Creek WSA and Weston Hill Recreation Area and would be visible to viewers in the areas.

Private and State Lands

Recreation is not a significant use of most private lands in the Project Area. Most developed recreation on private lands is municipal facilities in Project Area communities. CBM facilities are proposed for private and State lands outside of and adjacent to Gillette. Recreational facilities that are located on these lands include the Cam-Plex and the Cam-Plex Park. The Cam-Plex facilities occupy about 1,000 acres at the east side of Gillette, and include a theater, a convention/exhibit hall, two large multi-purpose pavilions, rodeo grounds, RV campgrounds, a horse race track, a 21-acre park, and picnic area. The development of CBM facilities would not be compatible with public use of these facilities.

Other recreational facilities located near the municipal boundaries and near to proposed facilities include the Dalby Memorial Park, the Country Club Golf Course, and the Bell Knob Golf Course. These facilities would experience indirect effects from the Project because the recreational experience would be affected by the sight and noise of CBM construction and operation. There are no other recreational sites on private lands or within municipal boundaries that would be affected by Project activities.

Developed recreational opportunities on State lands include big game hunting in the Amsden Creek Winter Game Refuge and the Bud Love Wildlife Habitat Management Area. Both areas are managed with NSO leasing stipulations and would not be impacted by Project activities.

Alternative 2

Alternative 2 differs from Alternative 1 in the distribution of produced water among the methods for handling produced water and the compression of gas. The numbers and distribution of CBM and non-CBM wells are the same as evaluated for the Proposed Action. The effects to the developed and dispersed recreational uses from the development of CBM wells and the ancillary facilities other than facilities for handling produced water is identical to those described for the Proposed Action.

Under Alternative 2, there would be 76 LAD sites in the Project Area, an increase of 181 percent over the LAD sites proposed for the Proposed Action. The proposed 117 containment reservoirs would be a decrease of 18 percent from the Proposed Action. The large increase in LAD sites over the Proposed Action would result in larger areas of modified vegetation as described for the Proposed Action. Development of additional LAD sites would potentially have an adverse effect on wildlife and, consequently, hunting opportunities in the affected subwatersheds because the modified vegetation would affect the quality of the wildlife habitat. The smaller number of containment reservoirs would reduce the opportunities for some wildlife-related recreational opportunities relative to the opportunities resulting from the Proposed Action by providing areas for viewing wildlife, hunting waterfowl, or public fishing. There would be a larger potential for adverse impact to recreational opportunities in the Project Area from Alternative 2.

Alternative 3

Under the No Action alternative, there would be no CBM development on federal leases within the Project Area. Federal leases are located on private as well as federal lands. Development would continue on State and private leases and would include access and pipelines across federal lands to reach proposed State and fee wells. There would be a total of 15,458 CBM wells developed on State and private leases. The No Action alternative includes all of the effects to recreational opportunities and the recreational experience described for the Proposed Action, but differs from the Proposed Action in the number of wells to be developed, the acres of land to be disturbed temporarily or removed from existing uses during the life of the Project and the volume of water to be produced from CBM wells. The effects to recreation are expected to be considerably less than those described for the Proposed Action because a small number of facilities would be developed and a small number of acres would be removed from existing uses. Tables 2–29 through 2–32 summarize the facilities proposed for Alternative 3 and the short- and long-term disturbance for each sub-watershed.

Under Alternative 3, there would be 13 LAD sites in the Project Area, a decrease of 52 percent from the LAD sites proposed for the Proposed Action. The proposed 68 containment reservoirs would be a decrease of 52 percent from the Proposed Action. The Fewer LAD sites would result in smaller areas of modified vegetation than described for the Proposed Action. There would be a lesser effect on wildlife than the Proposed Action. The smaller number of containment reservoirs would reduce the opportunities for some wildlife-related recreational opportunities relative to the opportunities resulting from the Proposed Action by providing areas for viewing wildlife, hunting waterfowl, or public fishing. There would be a lesser potential for adverse effects to recreational opportunities in the Project Area from Alternative 2 than would occur from the Proposed Action.

Cumulative Effects

The cumulative effect of the development of roads and well facilities would be improved vehicular access to the area. However, a majority of this access would be not be available to the public since much of the surface is privately owned and there are no recreational facilities.

The cumulative acreage likely to be affected long-term by production facilities under the Proposed Action (approximately 6,514 acres) is not likely to have a cumulative effect on hunting and fishing opportunities. Recreational hunting and fishing opportunities, which are controlled by landowners on private lands, may increase locally within portions of the area, as populations of game animals and game fish rise locally during the life of the Project in response to increased availability of surface water and forage. This small cumulative enhancement of recreational opportunities in the immediate vicinity of any reservoirs created would be temporary and would last only as long as water production continues. Although the Project is not expected to affect the level of visitation or growth in the counties, recreation visitors may become accustomed to recreational experiences near ponds or flowing water over the life of the Project. Visitors would have to accept anticipated reductions in surface water when water discharge ends.

Cumulative effects from the increased human presence associated with the cumulative energy development in the PRB are likely to cause increased levels of legal and illegal hunting. Conversely, the mines in the area have become refuges for big game animals during hunting seasons since most are closed to hunting.

Energy development-related secondary effects to recreational land uses have and would continue to result from human population growth. The demand for outdoor recreational activities, including hunting and fishing, have increased proportionately. However, at the same time these demands are increasing, wildlife habitat and populations are being affected by increased surface disturbance.

Demand for hunting licenses may increase to the point that a lower success in drawing particular licenses would occur; hunting and fishing may become less enjoyable due to more limited success and overcrowding; poaching may increase; the increase in people and traffic has and may continue to result in shooting of nongame species and road kills; and increased off-road activities have and would continue to result in disturbance of wildlife during sensitive wintering or reproductive periods. Travel management during hunting season, including seasonal road closures to the public, could disperse hunters throughout the area, reduce hunting pressure in popular areas, and facilitate a more enjoyable experience for hunters.

It is not anticipated that the Proposed Action and proposed CBM development on State and private lands would result in any increase in population because the proposed workforce would consist of local hires. However, the overall population of Project Area counties may increase as a result of future coal mine development and expansion of existing mines. CBM fields may continue to be developed within the Project Area and may contribute to ongoing population growth. Any future growth may contribute increased visitor use of the developed facilities.

Noise

The EPA (EPA, 1974) has established an average 24-hour noise level as the maximum noise that does not adversely affect public health and welfare. No definitive data has been established concerning noise levels that affect animals. No laws concerning quantitative noise levels have been established by the State of Wyoming or the BLM. Therefore, lacking any quantitative statutory guidelines, noise levels above 55 dBA at a residence, school, medical facility, or a special recreation area are considered a noise impact.

Noise levels would be temporarily elevated above the general rural background noise of 35 to 40 dBA during the construction of facilities. Construction-related noise would result from construction equipment, vehicle traffic, and drilling rigs. However, activities at each drill site would occur for only one to five days during the short drilling period. Therefore, well pad construction would not cause any significant noise impacts. Construction related noise would last longer for the 60 to 90 days required to construct a compressor station or less for pipeline construction. However, the noise from each construction site would be relatively short-term and the individual sites would be sufficiently widespread so that elevated noise levels from each site would not overlap in time or space with another site.

The highest operational noise would occur around compressor stations. Under all alternatives, two types of compressor engines would be installed. Small booster compressor engines rated at 350 horsepower would be operated to gather natural gas from wells to the larger compressor stations. A maximum of six booster compressor engines could be operated at any location. At the larger compressor stations, large reciprocating engines rated at 1,650 horsepower would be installed to facilitate transmission of natural gas to high-pressure transmission pipelines. Typically, three or six of the larger engines would be installed at any location.

Noise has been measured at typical compressor units (USGS, 1981). A noise level of 77 dBA from one large compressor engine can be expected at 50 feet from a compressor building since all compressors would be installed in enclosed buildings because of the harsh Wyoming winter weather. Noise from the smaller booster compressor engines would be slightly lower or approximately 73 dBA at 50 feet.

The effect of multiple noise sources is not arithmetically additive, but rather is a logarithmic addition. The total effect of multiple co-located noise sources is characterized by the following relationship (Harris, 1991):

$$L = 10 * LOG (10^{L1/10} + 10^{L2/10} + \ldots\ldots + 10^{Ln/10})$$

where: L1, L2, ..., Ln are the source sound levels of individual collocated sources.

L is the overall noise level.

LOG is the common logarithm base 10.

Therefore, the preceding equation is used to calculate the overall noise of six large compressor engines operating simultaneously with a source noise of 77 dBA from each engine. The resultant overall source noise would be 84.8 dBA at 50 feet from the enclosure building. The overall noise from a compressor station with three engines would be 81.8 dBA at 50 feet. For the smaller booster engines, the overall noise would be 80.8 dBA at 50 feet for six engines, and 77.8 dBA at 50 feet for three engines.

To calculate the noise impact at a distance from the compressor station, the noise levels were mathematically propagated using the Inverse Square Law of Noise

Propagation (Harris, 1991). Briefly, this formulation states that noise decreases by approximately 6 dBA with every doubling of the distance from the source. This methodology is an accurate assessment of noise propagation and is represented as:

$$L_2 = L_1 - 20 \log (R_2/R_1)$$

where:

L_2 = noise level at a selected distance R_2 from the source

L_1 = noise level measured at a distance R_1 from the source.

The preceding equation was applied for the source noise for configurations of three and six engines at a compressor station for both types of compressors. Table 4–101 shows the noise levels at selected distances from the two types of compressor engines with three- or six-engine configurations. The bolded noise levels correspond to the approximate distance where the noise produced by the compressor stations would be less than 55 dBA. As long as compressor stations would be constructed at least this distance from existing residences, no significant noise impact would occur at the residence. Compressor stations would have to be constructed further from grouse leks to ensure noise from the stations would be less than 49 dBA.

Table 4–101 Predicted Noise Levels from PRB Compressor Stations

Distance (feet)	Noise from 6 Large Engines (dBA)	Noise from 3 Large Engines (dBA)	Noise from 6 Booster Engines (dBA)	Noise from 3 Booster Engines (dBA)
200	72.8	69.8	68.8	65.8
400	66.7	63.7	62.7	59.7
600	63.2	60.3	59.2	56.2
800	60.7	57.7	56.7	**53.7**
1,000	58.8	55.8	**54.8**	51.8
1,200	57.2	**54.2**	53.2	50.2
1,400	55.9	52.9	51.9	48.9
1,600	**54.7**	51.7	50.7	47.7
1,800	53.7	50.7	49.7	46.7
2,000	52.8	49.8	48.8	45.8

Socioeconomics

Alternative 1

Effects to the socioeconomic structure of Campbell, Converse, Johnson, and Sheridan counties, including population, housing, and employment, resulting from drilling and constructing ancillary facilities, such as roads and pipelines, are expected to occur over a 10-year period under the Proposed Action. The socioeconomic effects resulting from CBM production activities are expected to occur over the proposed life to the Project, about 20 years. The number of CBM wells are provided in Table 4–102 and the number of non-CBM wells are provided in Table 4–103.

Table 4–102 CBM Wells Proposed by Mineral Ownership

	Number of Wells Drilled on Federal	Number of Wells Drilled on State	Number of Wells Drilled on Fee	Total
Campbell	13,448	1,018	6,834	21,300
Converse	114	20	42	176
Johnson	7,764	756	2,260	10,780
Sheridan	2,583	874	3,654	7,111
Total	23,909	2,668	12,790	39,367

Table 4–103 Non-CBM Wells Proposed by Mineral Ownership

	Number of Wells Drilled on Federal	Number of Wells Drilled on State	Number of Wells Drilled on Fee	Total
Non-CBM Proposed by Mineral Ownership				
Converse	120	9	71	200
Johnson	176	18	59	253
Sheridan	18	7	45	70
Total	1,855	214	1,131	3,200

Most of the production is expected to occur in Campbell and Johnson counties. For this reason, Campbell County and Johnson County are likely to be affected by fiscal and social effects. Sheridan County also would have extensive effects and all three counties would have a greater extent of effects than Converse County. Most of the new wells (63 percent) and facilities would be constructed in the two sub-watersheds, the Upper Powder River sub-watershed, which is within approximately one-third of Campbell County and two-thirds of Johnson County, and the Upper Belle Fourche sub-watershed, which is within Campbell County. Other sub-watersheds with relatively high numbers of wells and facilities include: the north portion of Clear Creek and Upper Tongue River, which are within Sheridan County; Crazy Woman and the south portion of Clear Creek, which are within Johnson County; and Little Powder, which falls in Campbell County. Most of the employees are likely to primarily reside in Gillette and Wright, but employees also would live in Sheridan, Buffalo, and other smaller communities within the Project Area.

Socioeconomic effects resulting from CBM development are a concern because considerable energy-related development has occurred in and around the affected counties during the past 30 years. Wyoming's economy has been structured around the basic industries of extractive minerals, agriculture, tourism, timber, and manufacturing. Many Wyoming communities depend on the mineral industry for much of their economic well being. The 1999 assessed valuation on all minerals produced in Campbell, Converse, Johnson, and Sheridan counties accounted for 36.9 percent of the State of Wyoming's total assessed valuation (WDR 2001). In the same year, assessed valuation on minerals produced in the State accounted for 32 percent of the State's valuation (Powder River CBM Information Council 2001).

Several forecasts have been developed for future natural gas supply and demand in the PRB. The State of Wyoming's Consensus Revenue Estimating Group (CREG) develops mineral price and production forecasts for major mineral commodities twice each year to estimate the State's anticipated revenues. According to the CREG, natural gas price projections have been increased significantly over the short term. The estimated price was increased from $2.85 per thousand cubic feet (mcf) to $3.50 per mcf for calendar year 2000, and from $2.50 per mcf to 4.50 per mcf for calendar year 2001. Calendar year 2002 estimates were anticipated to increase from $2.25 per mcf to $3.00 per mcf. The long-term price estimate was held at $2.25 per mcf over the rest of the forecast period (2006). The average price expected over the FY 2001 period (July 2000 through June 2001) was increased from $2.67 per mcf to $5.00 per mcf. Prices are then expected to moderate, but still remain significantly higher than previously forecasted levels over the relative short term (Wyoming Division of Economic Analysis 2001).

Natural gas production estimates were anticipated to increase slightly by 50 million mcf per year over the forecast period for the State of Wyoming. Coal bed methane production figures were revised from 135 million mcf to 145 million mcf for 2000 production, from 190 million mcf to 175 million mcf for 2001, and from 250 million mcf to 225 million mcf for 2002 (CREG 2001).

CBM production under the Proposed Action would be generated by the 12,077 wells approved or constructed before 2002 and the 39,697 CBM wells drilled from 2002 through 2011. The revenue generated from the existing wells has already begun and those revenues are addressed in the cumulative effects. The assessed sales value from new CBM and new conventional wells are described below.

In January 2001, CREG estimated a natural gas price of $2.25 per mcf for the period 2001 to 2006 (Wyoming Division of Economic Analysis 2001). This price also was assumed for this analysis. Assuming each CBM well produces 400 million mcf (DeBruin, Lyman, Jones and Cook 2001), each well would generate an estimated $900,000 (constant 2001 dollars) total sales value. Using $2.25 per mcf, Alternative 1 is expected to contribute a sales value of nearly $35.4 billion (constant 2001 dollars) over the life of the Project to the local, State, regional, and national economies.

Non-CBM (conventional oil and gas) under the Proposed Action would be generated by 3,200 conventional wells drilled by the end of 2011. The analysis assumed the conventional wells produce 80 percent oil and 20 percent natural gas (Crockett 2001). Also, for the purposes of this analysis, a $25.25 per barrel of equivalent (BOE) over the life of the Project was assumed based on CREG estimates between 2001 and 2006). The assumed production rate of conventional wells, which average 137,500 BOE (Crocket 2001), for the their 15 year productive life (BLM 2001) was also used for the purposed of this analysis. Using these estimates, over its productive life, each conventional well would generate an estimated $3.5 million (constant 2001 dollars) total sales value. The total sales value of conventional wells would be approximately $5.5 billion (assuming a 50 percent success rate), of which $4.4 billion would be from oil production and $1.1 billion would be from natural gas over the life of the Project.

Overall, assuming 100 percent success rate, CBM well development would contribute sales valued at nearly $35.4 billion (constant 2001 dollars) over the life of the Project to the State, regional, and national economies and assuming 50 percent success rate, non-CBM would contribute sales value at nearly $5.5 billion. The total sales value resulting from these success rates would be $40.9 billion in sales value. These values do not account for the sales value from the associated facilities or equipment and supplies associated with the facilities for CBM and non-CBM wells, which would contribute to an even higher sales value and thus increase the tax revenue within the Project Area.

Population

Oil and gas operations play an important direct and indirect role in the local economy through jobs that are created in the community. Additional jobs result in additional personal income, and improved and or additional community needs, such as schools, utilities, and transportation systems.

The Project is not expected to result in significant short- or long-term effects to local population conditions. It is assumed that most of new full-time workers would be recruited from communities within the Project Area and that construction employment and contractors would be available in the region (Keanini 2001a).

Substantial CBM exploration and development activities are currently ongoing in the counties. To the extent that additional non-local contractors or permanent employees are needed, they may relocate to the area for a limited period of time (2 to 5 years) during the major construction phase of the Project (Keanini 2001b). Therefore, it is expected that only a small to moderate increase in population growth would occur.

It is not anticipated that this Project employment would substantially affect demographic characteristics of any of the counties in the Project Area.

Direct and Indirect Employment

Implementation of Proposed Action would have a substantial effect if it resulted in a negative change in local economic conditions or wages, resulted in a short- or long-term reduction in employment, or created the potential for a boom/bust employment cycle. Development of the Project would be completed in approximately ten years from project initiation. The overall production lifetime of the wells is expected to be in the range of 7 years. This includes the 12,077 CBM wells already permitted in the Project Area, in addition to the 39,367 CBM wells and 3,200 non-CBM wells proposed. Both direct Project employment (e.g. positions with one of the Companies or contractors hired for construction, production, and decommissioning) and indirect or secondary employment (jobs that become available in support industries as a result of Project activities, such as parts and materials production, equipment refueling, etc.) would arise as a result of project activities.

Direct Employment

Implementation of the Project would create some additional employment opportunities in the Campbell, Converse, Johnson, and Sheridan counties; however, it is anticipated that most of the jobs would be hired from the local labor force (Keanini 2001a). It is speculative to determine as to which counties within the Project Area these employees will live and work, and therefore this was not evaluated for this analysis. Table 2–16 identifies estimated employment requirements for the Proposed Action associated with CBM and the following text identifies employment needs for non-CBM activity and additional facilities required. Non-CBM estimates are based on wells and roads projected; however, it is assumed that adequate workers required for non-CBM compressor, pipeline, and utility lines construction are accounted for in the CBM facility estimation. Due to the long-term nature of the Project, coupled with fluctuation in natural gas economics and the Companies involved in the leases, developing exact projections of employment is difficult. Therefore, the following paragraphs provide a reasonable estimate of what employment effects can likely be expected with project implementation.

Construction and Installation

The primary influx of employment opportunities associated with the Project is expected to occur in the first ten years of the Project, during the development phase. During this phase, the primary activities would be well drilling and completion and construction of associated ancillary facilities (e.g., access roads, pipelines, power lines, and compressor stations). As shown in Table 2–16, it is anticipated that these activities would require 1001 workers per day. After the initial 10-year development period, rigs would drill replacement wells for those depleted plugged and abandoned, or for isolated filed development. Non-CBM development would require approximately 42 workers per day for the life of the Project.

Employment opportunities are expected to be the greatest over the first ten years (the construction phase) and then constant over the remaining life of the Project. Employees and contractors would be hired or reassigned because, for the most part, they already work in the area to construct and maintain roads and well pads, construct utility trenches, and install underground gas pipelines, water pipelines, and utility lines. Local contractor jobs would include gravel and water truck drivers, heavy equipment operators, and pipeline workers, comprised primarily of workers currently located within the Project Area.

Some components of the Project's workforce would be non-local transient construction workers with specialized expertise required to drill and complete wells. It is assumed that these workers would reside in the Project Area for about six months each year (May through November) during the construction season. It is assumed that the majority of these workers would reside in motels while they are working in the area and would not bring families with them. Many of these contractors would leave the Project Area once the construction and development phase of the Project is finished.

Necessary skills would include: pump and pipeline maintenance, compressor and electric motor maintenance, and production monitoring. Many of these positions would likely be filled by workers currently underemployed in service or trade sector jobs. Some jobs that require a higher or different level of expertise may be filled by non-local workers.

Operation /Maintenance and Decommissioning

Once the CBM wells have been installed some level of sustained permanent employment (as described in Table 2–16) would be related to maintenance and operation of the fields over a 20 year period. Additionally, gradual reclamation of the inactive wells, and associated access roads would be an on going effort in the later years of the Project. Fewer workers would be required to perform these functions. Approximately 378 CBM workers and approximately 17 non-CBM workers would be required for the operation and maintenance phase, and the majority of these workers would be pumpers. Implementation of remote monitoring is anticipated to decrease the number of workers traditionally required for operation and maintenance.

The final stage of the Project life cycle involves the reclamation and abandonment of facilities, which may also trigger 595 jobs for CBM and approximately 8 jobs for non-CBM wells for a period of ten years, during which the various facilities would be dismantled and removed or abandoned in place and surface areas are reclaimed.

As a result of the Proposed Action, at a minimum it is assumed that 2,041 employees would be required for the life of the 20-year Project, consisting of annual employment of 1,974 CBM workers, 67 non-CBM workers. It is assumed, that due to the revolving nature of CBM, these employees already live in the area and would be available for work (Keanini 2001a).

Indirect Employment

In addition to the CBM and non-CBM related jobs to the local economy, during the life of the Project purchases and expenditures made by Project employees within and outside of the affected counties, which would in turn extend the length of time of secondary jobs for the life of the Project. However, because most of these jobs have been filled by employees living in the area, it is anticipated that few secondary jobs would be created, but may sustain for a longer period of time than previously anticipated. Since the vast majority of service and retail trade activity occurs in the Gillette, Wright, Buffalo, and Sheridan communities, it is assumed that most of these jobs would be created in these or nearby communities in Project Area.

Wages

The Project also would contribute to the local economy through the generation of earnings that would be spent on items such as housing, food, goods and services. In addition, economic benefits would occur as a result of the Companies spending on purchases of equipment and supplies from local area vendors.

The wages and salaries paid to long-term Project employees would contribute and estimated total annual personal income to the local economy of $81.6 million (in constant, 2001 dollars) per year, using an average annual income of $40,000 (Powder River CBM Information Council 2001). Over a 20 period, these local jobs created by the stimulation of the economy would contribute an additional $1.6 billion. The average annual income would primarily be contributed to the affected counties.

As the Project life expectancy nears completion, additional costs and expenditures would occur as wells are plugged and decommissioned. Projections of these costs are unavailable at this time. Both expansion of existing businesses and creation of new business can be anticipated due to the increase of longevity of existing jobs. However, once the development phase of the Project is completed, a reduction in service and trade sector employment can be anticipated. Some additional earning from the indirect employment also can be expected and these earnings would be spent in, and contribute to, the local economy. Once the development phase of the Project is completed, indirect earnings from secondary employment would eventually be reduced.

Local Economy and Potential for Boom/Bust Cycle

Implementation of the Project would create both primary and secondary employment opportunities, contribute to the local economy, and provide a substantial source of revenues for local agencies through the collection of royalty taxes. If current estimates and plans are realized by each of the Companies involved in the Project, it is assumed employment opportunities would occur primarily in the first 10 years of the Project, while revenues may extend for as long as 20 to 30 years when Project activities and gas production would slow or cease and so would the associated economic benefits. Some concern was expressed during scoping related to the potential of Project activities to create a boom/bust economic cycle similar to what was experienced in the area in the early 1980s.

The potential for the Project to result in a substantial economic boom/bust cycle is low. If anything, by adding wells to an area that may already be subject to slight Boom/Bust cycle activity, the Project would likely extend the locally strong economy longer than previously anticipated. While this Project would increase the importance of these sectors in the local economy, when compared to the overall economy these activities represent a relatively small share of the economy. Project activities are expected to begin and end in a gradual fashion, and a major lay-off or royalty reduction is not anticipated. Historically, the economies of counties with in the Project Area have been subject to the fluctuations associated with resource extraction and are probably less sensitive to this phenomenon than other areas. In addition, there are a number of other ongoing economic activities and concerted efforts by local authorities to diversify the local economy. These factors all lead to the conclusion that while the conclusion of Project activities would create a gap in employment and the economy, it is not expected that this gap would equate to the overall collapse of the region or a significant localized depression cycle. Although there is a risk for the oil and gas industry and potential for some risk to the local economies, there would be no risk to the overall economy of the Project Area.

Housing

To the extent that Project-created employment results in a concentrated housing demand or shortage, either short or long term, the effect of the Proposed Action would be considered significant. Effects shall be measured on both a local and regional level. If transient housing, e.g. man camps or motel rooms, would be required for short-term accommodations for construction or other laborers that are currently not available, the effect is deemed significant.

Minor employment or population changes are anticipated as a direct result of implementation of the Proposed Action. The increase in population would be small relative to the total population. Because most employees are expected to be hired locally, the demand for additional temporary or permanent housing within the near the Project Area likely may be met with the existing housing supply, depending on the vacancy rates during the period of operations. The majority of available housing units in the Project Area are located in the communities of Gillette, Wright, Sheridan, and Buffalo and it is anticipated that the majority of employees would live in Campbell County. Construction-phase workers who migrate into the area may reside in rental units within these communities. The rental vacancy rate for 2000 in the Project Area was 9.5 percent, only 0.2 percent lower than the State of Wyoming rental vacancy rate of 9.7 (Wyoming Division of Economic Analysis 2001c). There would likely be sufficient existing rental units to house the in-migrant portions of the workforce. Additional rental units may be constructed if the existing supply of vacant rental units becomes exhausted.

Community Facilities and Services

Roads, Water and Wastewater Systems, and Solid Waste Disposal

Access to portions of the Project Area from State and Federal highways would require the use of certain county roads. Project activities could potentially result in increased traffic and use of roads, including additional wear and tear from heavy vehicles. The increased use of county roads may increase maintenance costs to county special districts. Both paved and non-paved roads may be affected. The Project's effects on roads are described in the Transportation section of Chapter 4 starting on page 4–243.

Water would be required for construction and operation of the Project. Total water requirements would equal 6,896 acre-feet/year. The Companies would purchase water locally from a variety of sources, resulting in very minor shifts in water consumption from existing uses to this Project.

Because there is only a small population increase and subsequent housing demand expected with Project implementation, a significant effect on domestic water service provision (in terms of supply and conveyance systems) is not expected. In addition, neither the Project itself nor subsequent development resulting from Project employment (if any) is expected to have any effect on local wastewater facilities. Certain wastes would be disposed of onsite or recycled and other waste products would be disposed of at the local landfill. It is not anticipated that the addition of this waste stream would substantially affect the local landfills or their capacities.

Public Schools, Law Enforcement, Fire Protection, and Medical Facilities

Public schools in the region are not anticipated to experience significant increases in student enrollment as a result of the Project. Due to the limited population increases expected and the long-term time frame associated with the Project, public schools are not anticipated to experience the potential effects of substantial growth resulting from the Project. If current plans change, resulting in a significant number of Project workers being recruited from outside the local area who bring school-aged children with them, existing over-crowded conditions may be exacerbated.

Given that the population growth is expected to be consistent with typical growth rates, law enforcement, fire protection services, and medical are not expected to experience substantial effects as a result of Project implementation.

Public Finance

The Project would be considered to have a significant effect on public finance if local government fiscal conditions were impacted in such a way that revenues would not adequately provide public facilities and services at established levels.

Implementation of the Proposed Action would result in some level of both costs and benefits for the counties in the Project Area. Regarding financial costs, the primary Project-related impact is related to the use of county roads. Revenues used by these counties are generated through Federal mineral lease royalties, State payments in lieu of taxes, and interest earned on unanticipated funds. Additional Project-related costs to the counties may arise from administrative services. Examples of these costs include mapping, naming, and signing of new roads developed in the Project Area for emergency access, as well as other staff and administrative costs.

Mineral Royalties

The Mineral Management Service, U.S. Department of the Interior collects mineral lease royalties, for gas produced by wells completed on Federal lands. Federal royalties would be paid for each well producing from Federally owned oil and gas mineral estate. After administrative costs are deducted, half of the royalties would be retained by the Federal government, and used for the General Fund and various other funds. The remaining half would be distributed to the State of Wyoming, and used for schools, roads and other public works. For the purpose of this analysis royalties are estimated as percentage of the total Project yield for each well multiplied by the market price for the product.

It is estimated that about 39,367 CBM wells and 3,200 conventional wells would be completed on Federal, State and fee (private) minerals in the Project Area through the end of the estimated Project life. Substantial revenues would be generated through these mineral royalty payments. For this analysis, all Federal revenues are assumed to be a result of mineral royalties. It is assumed that revenue from leases and lease bonuses are not a part of this analysis.

Federal Royalties

For the purpose of analysis, federal royalties as a result of CBM activity have been estimate as $112,500 per federal well (using 12.5 percent of the estimated sales value of $900,000 for each well). Of the 39,367 CBM wells, up to 23,909 are expected to be CBM wells with federal minerals. The Project is expected to generate estimated federal royalties of $2.7 billion (constant 2001 dollars) from CBM wells over the life of the Project. One half of this total would be distributed to the federal government and the remaining half would go the State of Wyoming based on equivalent royalty rate.

For conventional wells, federal royalties have been estimated as $437,500 per federal well (using 12.5 percent of the estimated sales value of $3.5 million for each well). Of the 3,200 conventional oil and gas wells, up to 1,855 are expected to be federal wells. Assuming 50 percent success, the Project is expected to generate federal royalties of an estimated $406 million (in constant 2001 dollars) from conventional wells over the life of the Project. Approximately half of this total would be distributed to the federal government and the remaining half would go the State of Wyoming.

Overall, the Proposed action would result in approximately $3.1 billion in Federal royalties.

State Royalties

State royalties would be paid for each well producing from state-owned oil and gas mineral estate. State surface does not always correlate with state minerals, however, for the purpose of this analysis, state mineral data was calculated using state surface with non-federal minerals, due to the lack of available state mineral ownership for the entire Project Area. Using this assumption, there are 2,668 CBM wells on state minerals. For the purpose of this analysis, State of Wyoming royalties have been estimated as $150,030 per state well (using 16.67 percent of the estimated sales volume of $900,000 for each well). The Project is expected to generate approximately $400 million (constant 2001 dollars) in state royalties over the life of the Project. State royalties are placed in the permanent fund and used for schools and public institutions.

Using the assumptions above for State minerals, there are 214 conventional wells on State minerals. For the purpose of this analysis, State of Wyoming royalties have been estimated as $580,000 per state conventional well (using 16.67 percent of the estimated sales volume of $3.5 million BOE for each well). Assuming a 50 percent success rate, the Project is expected to generate approximately $62 million (in constant 2001 dollars) in state royalties from non-CBM over the life of the Project. State royalties are placed in the permanent fund and used for schools and public institutions.

Overall, the Proposed Action would result in approximately $462 million in state royalties.

Fee Royalties as a result of CBM and conventional well development

Fee royalties would be paid in royalty owner(s) of each well producing from the privately-owned mineral estate. The amounts paid, as fee royalties are not available to BLM. State and county governments do not receive royalties generated from the private mineral lands, but do collect severance and ad valorem taxes, and sales and uses taxes.

Sales and Use Tax Revenues

The Proposed Action would contribute to revenues of the State of Wyoming and its counties through sales and use taxes from the purchase and use of tangible goods. The State of Wyoming collects a four percent sales and use tax for each well, and the counties each collect one percent per well, for a total and use tax of five percent (BLM 1999). State taxes are retained by the State, and are partially disturbed to county and municipal governments. County sales and use taxes are distrusted primarily to the counties imposing the tax.

Sales and use taxes for oil and gas operations are applied to the following categories of tangible goods and services that are purchased or used during the CBM development: 1) coring or sampling; 2) well logging; 3) formation testing; 4) plugging and abandonment: 5) production casing: and 6) well completion. Generally those services directly related to drilling are not taxable. Well maintenance and repair services are taxable. Purchases of separate lines, tanks, and other units used in the collection, processing or transportation of oil and gas are taxable.

The taxable value per CBM well is estimated to be $36,000. This figure was calculated by applying an estimated factor of 60 percent (taxable goods and services) to a total drilling and completion CBM well cost of $60,000 (Western 2001). There would be 39,367 CBM wells resulting in $70.8 million in taxable drilling costs. For the purposes of this analysis non-CBM wells would be assumed to have similar sales and tax revenue per well, which would contribute an addition $5.8 million in taxable drilling costs. All of these expenditures are subject to sales revenue and tax, totaling $76.6 million paid to the State and the counties over the period of time that taxable goods and services are purchased (life of the Project).

Additional sales tax revenues will also be generated from the cost of the other water handling facilities. The sales tax over the life of the Project from water handling are shown in Table 4–104. Because sales taxes are based on tangible goods and the design of the water handling methods are on a conceptual level, tangible goods were based on estimates and assumptions. These costs are incomplete and are only presented to be used as a comparative analysis. The total sales tax revenue generated from water handling of this alternative is estimated to be $73.94 million for the life of the project.

Overall, CBM and non-CBM activity in the Proposed Action would result in approximately $150 million in sales tax returned to the State and counties, over the life of the Project.

For CBM wells, severance taxes on fee wells are calculated at a six percent rate for the State of Wyoming. Based on a sales value of $900,000 per well, the severance tax over the life of the Project is expected to be $ 54,000 per well. As a result, the 39,367 wells, would generate $2.1 billion in severance tax over the life of the Project paid to the State of Wyoming. Assuming a 50 percent success rate, the 3,200 non-CBM wells will generate $333 million in severance tax over the life of the Project paid to the State of Wyoming

Table 4–104 Water Handling Sales Tax Revenue

Type of water handing facility	Sales tax generated from water handling facility (millions)
Surface discharge (includes untreated, active treatment, passive treatment)	$29.0
Infiltration	$32.0
Containment[1]	$6.80
LAD	$1.01
Injection	$5.13
Total	$73.94

Note:

1. O&M unknown and therefore not included.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

Over all, CBM and non-CBM wells in the Proposed Action would result in approximately $2.4 billion in severance tax distributed to the State of Wyoming.

Local Ad Valorem Tax Revenue

Additional project revenues would be generated throughout the collection of an ad valorem/property tax levied on improvements constructed by the Companies. Since this tax assessment is based on value added to property, revenues would increase based upon the number and location of wells. No estimate of the assessment of improvements associated with well development was available, however, assessed value would be determined as a percentage of the actual cost of the facilities (BLM 1998). Theoretically, revenues would gradually increase over the first ten years in all four counties, provided a steady revenue stream for a period of years, and then decline as facilities are dismantled and reclaimed. These projections are subject to the number, locations, and life span of facilities and gas production.

County ad valorem tax rates for Campbell, Converse, Johnson, and Sheridan Counties vary slightly. In Campbell and Converse Counties the tax rate is 6.3 percent and in Johnson and Sheridan Counties the tax rate is 6.8 percent (BLM 2001). As shown in Table 4–105, Campbell County is estimated to receive $1.5 billion (constant 2001 dollars) in ad valorem taxes from CBM and non-CBM wells, the highest of the four counties in the Project Area. Johnson County is estimated to receive $690 million in ad valorem taxes from CBM and non-CBM wells, the second highest amount of the four counties in the Project Area. Sheridan County is estimated to receive $443 million in ad valorem taxes form CBM and non-CBM wells and Converse County is estimated to receiver 32 million in ad valorem taxes form CBM and non-CBM wells.

Table 4–105 Ad Valorem Taxes by County

	Wells Proposed	Ad Valorem Rate (percent)	Sales Value of the Well (dollars)	Net Ad Valorem (dollars)
CBM				
Campbell	21,300	6.3	900,000	1.2 billion
Converse	176	6.3	900,000	10 million
Johnson	10,780	6.8	900,000	660 million
Sheridan	7,111	6.8	900,000	435 million
Total				2.3 billion
Non-CBM[1]				
Campbell	1,339	6.3	3.5 million	295 million
Converse	100	6.3	3.5 million	22 million
Johnson	126	6.8	3.5 million	30 million
Sheridan	35	6.8	3.5 million	8.3 million
Total				355.3 million
Grand Total				2.7 billion

Note:
1. Assumes 50 percent success rate.
Source: BLM 2001c

Over all, CBM and non-CBM wells in the Proposed Action would result in approximately $2.7 billion in ad valorem taxes for the four counties within the Project Area that is used by the county governments to fund vital programs like public schools, hospitals, libraries and special districts, including conservation districts (Powder River CBM Information Council 2001).

Based on these assumptions, it is estimated that sales and use tax, severance tax and ad valorem tax revenues generated over the life of the Project would approximately be $5.2 billion ($2.7 billion ad valorem, $2.4 billion severance, and $150 million sales tax), which would represent a significant impact to the State and local economies.

Quality of Life

Project-related changes in existing ways of life that cause community discontent sufficient to raise conflict and organized response/opposition would be considered to represent a significant impact on quality of life. The perception of a “quality of life” is a very subjective and personal idea, which varies significantly by individual, location, and interests. Quality-of-life issues were raised as part of scoping for this Project; however, little or no information regarding a definition of this issue was provided by respondents. It is clear that no one would be in favor of a “poor” quality of life, but it is difficult to assess what specific aspects of a long-term project may cause an individual’s perception of quality of life to change in a negative manner. Additionally, many of the factors that would be considered by most to improve a quality of life (e.g., employment opportunities, municipal services, and vital economy) may or may not be achievable without some increase in factors seen to mar a quality-of-life perception (e.g., traffic increase, visual impairment, use of Federal lands for resource extraction, or influx of transient workers). Each of these factors is discussed in the following paragraphs.

Local Economy

Over time, the Project would result in effects that would be considered to both aid and deter from a common perception of a desirable quality of life. All of the social and economic topics described in this section would factor into a “quality of life”. It has been concluded that over the 20-year expected life span of the Project, increased employment in certain sectors would be realized. These opportunities (primarily within the first five years of Project development) would require skilled as well as unskilled labor. Many of these jobs could be filled by workers with similar skills who are currently residing in the Project Area. Employment opportunities and economic stability are a positive factor in the quality of life.

Visual Effects

Project development would noticeably increase activities on Federal lands throughout the Project Area. During the ten-year development phase, it is expected that there would be numerous ongoing drilling operations that would increase noise and dust and pose local visual impairment. Once wells are completed, well pad and pumping units would dot the landscape in certain areas. New road and pipeline corridors also would be noticeable. These effects are a necessary part of resource extraction activities in the area. These features may affect one’s perception of quality of life in terms of a visual impact experienced primarily during outdoor recreational activities in the Project Area. Localized visual effects, while unavoidable with Project implementation, can be lessened by some extent through mitigation, such as screening and painting.

Traffic Congestion

Implementation of the Project would result in an increase in traffic on Federal, State, and local roads. Truck and heavy equipment traffic on Federal lands, State highways, and county roads would increase. Some additional traffic on local community roads also may occur over time as new employees and Project activities create additional trips. The major traffic congestion would occur at locations along I-25, I-90 and SH-59 where vehicles and construction equipment would enter and exit the Project Area.

Climate and Air Quality

Climate and air quality are generally perceived as a factor in a definition of quality of life. The Proposed Action would have no effect on the regional climate. Furthermore, implementation of the Proposed Action is not anticipated to have significant effects to regional air quality. Since there are no changes to climate or significant effects or degradation to air quality anticipated, neither of these factors would affect quality of life.

Community Facilities and Services, Community Values

As described in previous sections, the Project would generate revenues currently not available to Campbell, Converse, Johnson, and Sheridan Counties. These revenues would likely be used for a variety of purposes, including funding for additional community facilities and services. While there may be a moderate increase in demand on existing services over time as Project activities proceed, these affects have not been determined to be significant. Careful planning and budgeting of revenue would allow municipalities to consider such things as school additions, parks, recreational facilities, additional law enforcement officers, and other services and facilities.

It would be highly speculative and very difficult to predict the Project's long-term impact on community values. Likewise, it would be difficult to assess whether or not implementation of the Project would have any effect on religion associated facilities in the area.

Crime

There is no information available that links natural gas development to increases in crime in a particular area. It would be impossible to predict increases or decreases in rates of crime resulting directly from Project implementation.

Property Values

Property values increase as result of high demand property and low supply. Property within the Project Area have increased in recent months, primarily due to the influx of population, CBM and non-CBM related, and the value of land due to royalties associated with CBM activity. Property values may also be affected negatively by the presence of CBM activity and associated activity (visual, traffic, etc). It would be highly speculative to quantify these effects positively and negatively given the size of the Project Area and the social factors related to property values.

Environmental Justice

This socioeconomic analysis provided a consideration of effects with regard to disproportionately adverse effects on minority and/or low-income groups, including Native Americans. No potentially adverse effects that disproportionately affect Native American tribes or minority and or low-income groups have been identified. Issues related to the social, cultural, and economic well-being, and health of minorities and low income groups (environmental justice) issues were evaluated during the analysis of the Proposed Action on socioeconomic resources, surface water and ground water quality, air quality, hazardous materials, and other elements of the human environment. No environmental issues were identified.

Implementing the Proposed Action would not have significant adverse affects on the social, cultural, and economic well being, and health of minorities and low-income groups. With regard to environmental justice issues affecting Native American tribes or groups, the PRB CBM Project Area does not contain tribal lands or Indian communities, and no treaty rights or Indian trust resources are know to exist for this area. There are no communities within the Project Area that would be likely to be physically impacted by the reasonably foreseeable development of CBM. Communities outside the Project Area, which would have a low potential to be affected from a water quality perspective, include the Northern Cheyenne and Crow Reservations in southern Montana, just north of the Upper Tongue River Watershed. It is not anticipated that there is a high potential for water quality degradation flowing into the reservations; however, water quality agreements and measures are discussed below with respect to environmental justice.

The Tongue River flows directly into the Northern Cheyenne and Crow Reservations. As stated Chapter 2, the Companies are required to monitor and report produced water volumes and quality to WDEQ pursuant to NPDES permit requirements. Discharges are required to meet all applicable WDEQ-WQD water quality standards and regulations at all times. The Companies on a voluntary basis have also initiated and funded several studies that are intended to address the cumulative effects of the collective water discharges. Additionally, WDEQ and MDEQ have initiated the Montana and Wyoming Powder River Interim Water Quality Criteria Memorandum of Cooperation (MOC). The intent of the MOC, with respect to environmental justice, is to recognize a responsibility and an opportunity to collaboratively protect water quality in the Powder River Basin to facilitate the development of CBM activities in the respective states. Under the MOC, the State of Wyoming recognizes Montana’s downstream interests and has committed to apply certain limits on the development o CBM activities, during the term of the cooperative effort and would work with and support Montana’s efforts to develop long-term water quality standards and an equitable allocation of the assimilative capacity if one exists.

Alternative 2

Alternative 2 specifically relates to methods for handling produce water may slightly increase the land required to dispose of water. Such increase in land use may have negative visual implications ultimately affecting the “quality of life”.

Alternative 2A and 2B result in minimal change to the employment, wages, housing, infrastructure and royalties. Because of the water handling methods emphasized in these alternatives, CBM employment will increase to 2,260 for 2A and 2,112 for 2B, primarily resulting in the construction of these facilities. Non-CBM employment will be the same as Alternative 1. Therefore, an additional $1.86 billion (2A) to $1.73 billion (2B) in annual wages over the life of the Project will be generated as a result of the additional employment from the water handling facilities. There may be a slight increase in infrastructure demands, however there will be an increase in traffic as a result of the water handling methods. The number of wells remain unchanged, therefore royalties are the same as the Proposed Action. Of all the socioeconomic issues, taxes will be the most affected, due to the cost of the water handling facilities. Specifically, sales tax revenues will be altered. Water handling as it applies to the cost of each method and number of each method is described below.

Alternative 2A Water Handling

Tax revenue generated from Alternative 2A may be slightly higher than that of the Proposed Action primarily due to the number and types and amount of water handling methods. The primary water handling cost of Alternative 2A is a result of emphasis of infiltration water handling. As shown in Table 4–106, the total sales revenue generated from the water handling portion of this alternative is estimated to be $94.4 million for the life of the project.

Table 4–106 Alternative 2A – Water Handling Sales Tax Revenue

Type of Water Handling Facility	Sales Tax Generated From Water Handling Facility (millions of dollars)
Surface Discharge	10.8
Infiltration	66.8
Containment[1]	7.90
LAD	3.44
Injection	5.52
Total	94.4

Note:
1. Operation and maintenance costs are unknown and not included.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

The total sales tax generated from drilling and water handling in Alternative 2A is estimated to be $171 million for the life of the project.

Alternative 2B Water Handling

Tax revenue generated from Alternative 2B is slightly higher than the Proposed Action, and Alternative 2A due to number of surface discharge and infiltration water handling methods. As shown in Table 4–107 the total sales tax revenue generated from water handling of this alternative is estimated to be $100 million for the life of the Project.

Table 4–107 Alternative 2B — Water Handling Sales Tax Revenue

Type of water handing facility	Sales Tax Generated from Water Handling Facility (millions of dollars)
Surface discharge	35.8
Infiltration	48.0
Containment[1]	7.2
LAD	3.44
Injection	5.52
Total	99.96

Note:
1. Operation and maintenance costs are unknown and not included.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

The total sales tax generated from the drilling and water handling of Alternative 2B is estimated to be $177 million for the life of the Project.

The two compression options for these alternatives include electrification of 50 percent of the booster compressors, with the difference using gas-fired booster compression and electrification of 100 percent of the booster compressors. The cost associated with these alternatives varies depending on the price of gas versus the price of electricity. For the purpose of this analysis, if the price of electricity is assumed to be $0.0372/kilowatt hour (KWH)(Browne 2001) and a fully loaded engine can produce the equivalent of .746 kilowatt hours (kWh), then electric generation would cost approximately $0.02775 per horse power hour (hrsp-hr).

Assuming the gas-fired engine requires .01 mcf per hspr-hour (Zavadil 2001) and gas is at $2.25 per mcf (Wyoming Division of Economic Analysis, 2001), gas-fired compression would cost approximately $0.02250 per hrsp-hr. Therefore, the price of gas would represent approximately a 19 percent savings. Additionally, because the gas is used on these compressor engines, there is some savings from the basis differential, gathering and compression rates, transport deductions, and royalty and ad valorem savings, which ultimately result in lower net fuel cost. For instance, the fuel cost might be $3.00/mmbtu, however after these deductions, the true cost for fuel is only $1.32/mmbtu (Keanini 2001b).

For the purpose of this analysis, given the current projected price of natural gas and electric, natural gas booster compressor units would be more economical to the operators. Electric booster compression units add no economic value to the operators or the community.

Alternative 3 — No Action

Under the No Action Alternative, additional natural gas drilling would not be authorized on Federal leases within the Project Area. However, drilling could still occur on State and private land. The No Action Alternative would result in approximately 637 fewer jobs created in the Project Area over the life of the Project and therefore approximately $510 million in annual income within the counties of the Project Area.

Expenditures made by the Companies and local tax revenues would be reduced substantially because 23,909 fewer CBM wells and 214 non-CBM wells would be drilled under this alternative, which also decreases the revenue generated from other facilities as well. In addition, the costs and benefits of the Project directed to Campbell, Converse, Johnson, and Sheridan counties would be reduced relative to the Proposed Action and Alternative 2. Federal mineral royalties from CBM alone would result in $3.1 billion less in sales value than in the Proposed Action. With no additional federal wells, there would be no additional Federal royalties available and no associated distribution of those royalties to the counties.

Tax revenue generated from Alternative 3 is lower than that of the Proposed Action and Alternative 2a and 2b, primarily due to decreased number of wells activity, which therefore decreases the number of water handling facilities. As shown in Table 4–108, $30.8 million tax will be generated from water handling. The total sales tax generated from drilling and water handling is estimated to be $61.3 million for the life of the project. The severance tax generated from this alternative is estimated to be $1.1 billion for the life of the project. The ad valorem tax generated from this alternative is estimated to be $1.06 billion for the life of the Project.

Additionally, not drilling Federal wells now may result in future negative production rates from Federal minerals. Drilling on private and State minerals would likely result in depletion of Federal minerals, and therefore potential Federal royalties, within portions of the Project Area. Modeling by Joe Meyer, BLM hydrologist, indicated that in an undrilled area within the Project Area, 9 to 22 pounds per square inch (psi) of pressure draw down would occur in as much as 1.5 miles from the boundary of the producing well after 18 months of production (BLM 2001b). Such significant pressure depletion is considered to be large and extensive (BLM 2001b). According to the same report, it is believed that undrilled Federal acreage, specifically within the Upper Belle Fourche River Subwatershed, may have been so severely depleted that an economic well is no longer feasible. It is anticipated, that depletion would continue to worsen and over a wider area within a portion of the Project Area, as CBM development continues (BLM 2001b).

Table 4–108 Alternative 3 – Cost and Sales Tax Revenue

Type of water handing facility	Sales Tax Generated From Water Handling Facility (millions of dollars)
Surface discharge	10.9
Infiltration	14.3
Containment*	2.94
LAD	.5
Injection	2.20
Total	30.8

Note:

1. Operation and maintenance costs are unknown and not included.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

Like Alternative 1 and 2, Alternative 3 would not have significant adverse Environmental Justice affects on the social, cultural, and economic well being, and health of minorities and low income groups for the same reasons stated under Alternative 1.

Cumulative Effects

Economic Consequences

The estimated cost of each alternative is provided in Table 4–109. The costs were generated using cost assumptions provided in Table 4–110 and Table 4–111. For the purpose of this analysis, the following costs were not included in this cost analysis: land acquisition and holding; royalties; permitting; engineering; corporate overhead; management; taxes; interest; return of and return on investment; and time value of money. The costs that are estimated were utilized to estimate the socioeconomic impact to the affected communities.

Table 4–109 Estimated Cost of Each Alternative Over the Life of the Project

	Alternative 1 (billions of dollars)	Alternative 2a (billions of dollars)	Alternative 2a (billions of dollars)	Alternative 3 (billions of dollars)
Drilling, Operation and Maintenance, and Reclamation & Decommissioning	9.95	9.95	9.95	3.91
Water handling[1]	2.45	3.15	3.33	1.03
Total	12.4	13.1	13.3	4.94

Note:
1. Water handling includes Surface Discharge (Untreated, Active Treatment and Passive Treatment), Infiltration, Containment, LAD, and Injection.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

Table 4–110 Estimated Costs of Drilling and Reclamation for CBM and Non-CBM Wells

Drilling Activities	Estimated cost/ unit (over the life of the project)
Drilling and completion	$60,000 per well[1]
Well Infrastructure Cost per well	$22,000 per well[1]
Additional pd infrastructure	$16,000 per well[1]
Gathering Fees per Mcf	$20,000 per well[1]
Operation and Maintenance	104,000 per well[1]
Reclamation	$700 per acre[2]

Note:
1. Generated using Coal Bed Methane Operators Information Survey Results, prepared for the Eastern Research Group Inc and for the EPA. O&G Environmental Consultants, September 7, 2001.
2. Provided by Williams 2001.

Table 4–111 Estimated Cost of Water Handling Facilities

Water Handling (Includes labor)	Capital Cost of Construction cost per facility	O&M ($/bbl)	Reclamation cost per facility
Surface Discharge	$16,000	$.05[1]	$9,000
Infiltration	$154,000	$.06[1]	$136,000
Containment	$3,600,000	Unknown	$2,523,000
LAD	$500,000[1]	$.02[1]	$3,000
Injection	$90,0000[1]	$.06[1]	$9,000

Note:
1. Generated using Coal Bed Methane Operators Information Survey Results Report, prepared for the Eastern Research Group Inc and for the EPA. O&G Environmental Consultants, September 7, 2001.

Source: CBM Operators Information Survey Results Report, 2001; Williams, 2001; and Kolin, Greystone, 2001.

The cost was generated using data provided in the Coal Bed Methane Operators Information Survey Results Report, prepared for the Eastern Research Group, Inc. and for the EPA (O & G Environmental Consultants 2001). Additionally, Mike Kolin, P.E., of Greystone, generated estimated Project-related costs. (Kolin 2001). Because the conceptual level of this analysis does not present site-specific design and operation, the cost estimates are incomplete and are only for comparative analyses based upon a series of assumptions. In instances where cost was speculative, it was not included in the analysis (such as roads, pipelines, compressors, electric generation and other well-associated facilities) they were not included in this analysis.

Alternative 1

Although the cumulative economic value of CBM development under this alternative is very large, the cumulative workforce required for the Project is estimated to require approximately 349 employees for the 12,077 approved wells, 1,974 employees for CBM wells and facilities, and 67 employees for the 3,200 non-CBM wells. As a result, the average annual workforce required would be approximately 2,390 employees over the life of the Project. It is anticipated that these jobs filled from the local labor force. The annual payroll from these employees is anticipated to be approximately $95.6 million. Over the life of the Project, the annual payroll is estimated to be $1.9 billion. Employment opportunities will likely be greatest during the first ten years, and would gradually decrease over the life of the Project.

Because the local labor force would likely occupy new jobs, the increased population growth of the communities is not anticipated as a result of the Proposed Action. It is not anticipated that water systems, solid waste disposal, public schools, law enforcement, fire protection, or medical facilities would incur substantial additional effects from the Proposed Action. The local counties are accustomed to absorbing fluctuation in mineral development activities, which cause cycles of increasing and decreasing demands for workers, housing and community services. Much of the infrastructure required for the current population has been created and would sustain the current population.

In addition to salaries generated by the Project, extra revenue would filter to county levels through federal royalties, local ad valorem taxes, and sales and use taxes. Based on projected market prices, it is estimated that federal royalties would total approximately $3.1 billion over the life of the Project. The 12,077 permitted CBM wells are anticipated to generate an additional $151 million, totaling approximately $3.2 billion in federal royalties. Approximately half would be paid to the State of Wyoming and half to the federal government. State mineral royalties, sales and use tax, severance tax and ad valorem taxes would generate approximately $5.6 billion in revenue to be distributed by the State and counties, for schools, roads, and other community infrastructure.

Implementing the Proposed Action would have cumulative effects on social, cultural, and economic well being, and health of minorities and low income groups. With regard to environmental justice issues affecting Native American tribes or groups, the Powder River Basin Oil and Gas Project Area contains no tribal lands or Indian communities, and not treaty rights or Indian trust resources are known to exist for the area. Environmental effects associated with water quality north of the Project Area on or near the Crow and Northern Cheyenne Reservations will be subject to applicable approved water quality standards by the State of Montana and State of Wyoming.

Alternative 2

Alternative 2 includes all of the cumulative effects as described for the Proposed Action, but differs from the proposed action in water handling and compression. Alternative 2a and 2b would require approximately 287 and 138 additional employees than the Proposed Action.

Alternative 2A results in $21.1 million more sales tax from water handling and Alternative 2B results in $26.7 million more sales tax from water handling than Alternative 1. The use of natural gas fired booster compressors proves to be more economical for the operator and electric booster compressors provide no economic benefit to the community.

Alternative 3

Under this alternative, no additional wells would be drilled on federal lands. Approximately 637 new jobs would be created under Alternative 3 resulting in about $510 million in personal income and $1.1 billion less than under Alternatives 1, 2A, or 2B over the life of the Project. Implementation of Alternative 3 would result in a complete loss of all the federally related benefits and costs described in the Proposed Action because no federal royalties would be collected and the associated distribution of these royalties would not occur. Additionally, not drilling federal wells now may result in future negative production rates on federal minerals, due to depletion of minerals from drilling on state and private lands.

Mitigation

Through the analysis, several potential mitigation measures were identified to avoid, reduce, or minimize adverse effects to various resources. The BLM and FS can require these measures for leases with federal land surface, but can only recommend them for leases with non-federal land surface. These measures, which are in addition to those identified in the ROD for the Wyodak EIS and the Decision Record for the Wyodak Drainage EA, are discussed below by resource area.

Groundwater

1. Concerns exist about the interaction between reservoirs and shallow groundwater. At impoundment locations, it may be necessary to conduct investigation at representative sites around the basin to quantify impacts of water infiltration. This will help determine site-specific guidance on placement and design of CBM related impoundments.

Surface Water

2. Channel crossings by pipelines shall be constructed so that the pipe is buried at least four feet below the channel bottom.
3. Channel crossings by road and pipelines shall be constructed perpendicular to flow. Streams/channels crossed by roads shall have culverts installed at all appropriate locations as specified in the BLM Manual 9112-Bridges and Major Culverts and Manual 9113-Roads. Streams shall be crossed perpendicular to flow, where possible, and all stream crossing structures will be designed to carry the 25-year discharge event or other capacities as directed by the BLM.
4. Disturbed channel beds shall be reshaped to their approximate original configuration.
5. In plan of development areas where natural springs are present, operators shall be required to identify, inventory, and monitor these springs as part of their water management plan development.

Soils

6. The Companies shall submit a proposal for each LAD facility on federal lands for approval before initiating construction of the facility. At a minimum, the proposals shall (1) identify the site-specific chemical and physical characteristics of the soils; (2) provide a detailed operational plan for the facility (e.g., application rates; amendments for water, soils, or both; physical soil manipulations; winter operational plans); (3) include a monitoring plan; and (4) provide a mitigation plan.
7. The Companies shall segregate soil horizons during excavation of all project facilities and avoid mixing of soil horizons during stockpiling and redistribution of soils.

Cultural Resources

8. The Companies shall conduct CBM development in and around the Crazy Woman Battlefield in a way that preserves the eligibility of the site for nomination to the National Register of Historic Places. Approvals of APDs and PODs will require prior coordination with the SHPO and BLM's archaeologists.
9. For development within ½ mile either side of the Bozeman Trail, companies shall conduct evaluation of segments to determine their eligibility to the National Register of Historic Places. Mitigation of adverse impacts to segments of the trail that contributes to its eligibility for the NRHP will be determined on a case-by-case basis.

Air Quality

10. Roads and well locations constructed on soils susceptible to wind erosion shall be appropriately surfaced to reduce the amount of fugitive dust generated by traffic or other activities, and dust inhibitors (i.e., surfacing materials, non-saline dust suppressants, water, etc.) could be used as nec-

essary on unpaved collector, local and resource roads which present a fugitive dust problem. To further reduce fugitive dust, Operators could establish and enforce speed limits (15 – 30 mph) on all project-required roads in and adjacent to the Project Area. In developing the emission inventory for the air quality impact assessment, it was assumed that compressor engines would have an average potential NO_x emission rate of 1.5 g/hp-hr during operation. This reflects an upper emission level anticipated from currently available compressor engines.

11. A variety of potential emission reduction measures (BLM 1999) are available to further limit NO_x and other pollutant emissions. The evaluation was not intended to rank or identify a required emission reduction measure; the appropriate level of control would be determined and required by the applicable air quality regulatory agencies during the preconstruction permit process.

Vegetation

12. Construction equipment would be washed prior to being moved into and out of new work areas in order to remove any noxious weed seeds.
13. Existing infestations of noxious weeds that are within or adjacent to proposed well pads, access roads, or other facilities would be treated prior to construction to minimize the potential for spread of these infestations into newly disturbed areas.

Wetland/Riparian

14. Construction equipment would be washed prior to being moved into and out of new work areas in order to remove any noxious weed seeds.A
15. voidance of impacts to wetland/riparian areas is the preferred mitigation measure. Components of this mitigation measure include: avoidance of discharge in playas or closed basins, avoidance of discharge within or near existing wetland/riparian areas where discharge would result in rising water tables, potentially killing vegetation not adaptable to inundation, particularly cottonwoods and willows, and avoidance of disturbance within all delineated or recognized wetland/riparian areas.
16. To protect the biological and hydrologic features of riparian areas, woody draws, wetlands, and floodplains, all well pads, compressors, and other non-linear facilities shall be located outside of these areas.
17. Crossings of wetland/riparian areas by linear features such as pipeline, roads, and power lines shall be avoided to the extent practicable. Where crossings cannot be avoided, impacts shall be minimized through use of the following measures:
    - Site-specific mitigation plans shall be developed during the APD/POD or Sundry Notice approval process for all proposed disturbance to wetland/riparian areas.
    - Crossings shall be constructed perpendicular to wetland/riparian areas.

- For power lines, the minimum number of poles necessary to cross the area shall be used.
- Wetland areas shall be disturbed only during dry conditions (i.e., during late summer or fall), or when the ground is frozen during the winter.
- No waste material shall be deposited below high water lines in riparian areas, flood plains, or in natural drainage ways.
- The lower edge of soil or other material stockpiles shall be located outside the active floodplain.
- Drilling mud pits shall be located outside of riparian areas, wetlands, and floodplains.
- Disturbed channels shall be re-shaped to their original configuration.
- Reclamation of disturbed wetland/riparian areas shall begin immediately after completion of project activities.

Wildlife

18. The Companies shall conduct clearance surveys for special-concern species at the optimum time. This will require coordination with the BLM before February 1 annually to review the potential for disturbance and to agree upon inventory parameters.
19. For any surface-disturbing activities proposed in sagebrush shrublands, the Companies shall conduct clearance surveys for sage grouse breeding activity during the sage grouse's breeding season before initiating the activities. The surveys must encompass all sagebrush shrublands within ½ mile of the proposed activities.
20. The Companies shall locate compressor stations so noise from the stations at any nearby sage grouse display grounds does not exceed 49 decibels (10 dBA above background noise) at the display ground.
21. The Companies shall locate aboveground power lines, where possible, at least ½ mile from any sage grouse breeding or nesting grounds to prevent raptor predation and sage grouse collision with the conductors. Power poles within ½ mile of any sage grouse breeding ground shall be raptor-proofed to prevent raptors from perching on poles.
22. The Companies shall locate impoundments to avoid sagebrush shrublands, where possible.
23. The Companies shall fence all impoundments in bottom land areas that are developed for fisheries to exclude livestock.

Aquatics Species

24. Ponds developed for fisheries shall be fenced to exclude livestock; water quality in these ponds shall be sampled on an annual basis for selenium, TDS, and sodium bicarbonate, at a minimum.

25. Stream channel monitoring for erosion, degradation, and riparian health shall be conducted on an annual basis. Surveys shall include no less than one stream reach above all CBM discharges and several stream reaches below CBM discharges. Monitoring stations will be placed above all CBM outfalls and below all CBM outfalls, at least on mainstems.
26. Sub-watersheds that will receive CBM produced waters and shall be monitored for macroinvertebrates and fish populations include: Upper Tongue River, Upper Powder River, Salt Creek, Crazy Woman Creek, Clear Creek, Middle Powder River, Little Powder River, Antelope Creek, Upper Cheyenne River, and Upper Belle Fourche River. Sampling sites shall be established at existing flow and water quality monitoring stations where possible. Sampling shall occur on an annual basis during low flow periods, and all data collected shall be entered into a central database. At least two sampling locations per stream or river shall be established in these watersheds:
    - Upper Tongue River – 1) between the Wyoming/Montana border and below all CBM discharge points; and 2) above CBM discharge points.
    - Upper Powder River – 1) above Clear Creek at confluence; 2) above Crazy Woman Creek at confluence; 3) below Salt Creek at confluence; and 4) below other tributaries that may contribute flow to the Upper Powder River.
    - Salt Creek – 1) above Upper Powder River at confluence; and 2) above CBM discharge points.
    - Crazy Woman Creek – 1) above Upper Powder River at confluence; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to Crazy Woman Creek.
    - Clear Creek – 1) above Upper Powder River at confluence; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to Clear Creek.
    - Middle Powder River – 1) between the Wyoming/Montana border and below all CBM discharge points; and 2) below confluence of Upper Powder River and Clear Creek.
    - Little Powder River – 1) between the Wyoming/Montana border and below all CBM discharge points; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to the Little Powder River.
    - Antelope Creek – 1) between eastern Project Area boundary and below all CBM discharge points; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to Antelope Creek.
    - Upper Cheyenne River – 1) between eastern Project Area boundary and below all CBM discharge points; 2) above CBM discharge

points; and 3) below other tributaries that may contribute flow to the Upper Cheyenne River.

- Upper Belle Fourche River – 1) between Campbell/Crook County line and below all CBM discharge points; 2) above CBM discharge points; and 3) below other tributaries that may contribute flow to the Upper Belle Fourche River.

- A minimum of 21 sites (as above) would need to be sampled on an annual basis in order to monitor aquatic health within the Project Area.

Threatened, Endangered, or Sensitive Species

27. For any surface-disturbing activities proposed in potentially suitable habitats for the Ute ladies-tresses' orchid, the Companies shall conduct clearance surveys according to the FWS' guidelines (FWS 1992) before initiating the activities. The surveys must encompass all potentially suitable habitats within ½ mile of the proposed activities.
28. The Companies shall conduct clearance surveys for threatened, endangered, or other special-concern species at the optimum time. This will require coordination with the BLM before February 1 annually to review the potential for disturbance and to agree upon inventory parameters.

Transportation

29. The Companies shall use gravel, water, or other dust suppressors, as needed, to reduce dust associated with facility access roads.
30. The Companies shall provide georeferenced spatial data models depicting, wells, roads, pipelines, power lines, reservoirs, discharge points, and other facilities to the BLM semi-annually. The models will depict the as-built locations of all facilities.
31. Companies should enter into maintenance agreements with the counties to ensure the county roads are adequately maintained.

Visual Resources

32. The Companies shall complete the following measures, where possible: use existing well pads where feasible, use vegetative and topographic screening when siting well locations, avoid highwall cuts, and shield drilling rig lights.
33. Within the designated VRM Class II corridors along Interstate 90 and State Highway 14, all project facilities on BLM surface shall be screened completely from these highways.
34. The Companies shall mount lights at compressor stations on a pole or building and direct them downward to illuminate key areas within the facility while minimizing the amount of light projected outside the facility.

Unavoidable Adverse Effects

The sections below describe the unavoidable adverse effects identified during the analysis.

Groundwater and Surface Water

Unavoidable adverse effects to groundwater and surface water would occur. These include the long-term removal of water from the coal aquifers as they are depressurized by the wells. The volume of water in other aquifers would be increased through infiltration and injection. The quality of surface waters would change in response to the discharges of CBM produced water and disturbances of soils and vegetation throughout the Project Area.

Air Quality

Some increase in air pollutant emissions would occur as a result of the development alternatives; however, based on the “reasonable, but conservative” modeling assumptions, these impacts are predicted to be below applicable significance thresholds.

Vegetation

Unavoidable direct and indirect adverse effects would occur under each of the four alternatives. The extent of disturbance would be essentially equivalent for Alternatives 1 and 2, but approximately half the magnitude for Alternative 3. Areas disturbed under each alternative would be subject to a high potential for invasion of noxious weeds and would require substantial effort to prevent and control the spread of these weeds. Restoration of biodiversity in disturbed areas would require an extended period of time and would likely be a function of the spread of native plant species from outside of disturbed areas, a time-consuming process that can be severely delayed by noxious weed invasions. Vegetation types providing crucial wildlife habitats would not likely be replaced for an extended period of time, potentially causing adverse effects to wildlife.

Wetland/Riparian Area

Unavoidable direct and indirect adverse effects would occur under each of the three alternatives. The extent would be essentially equivalent for Alternatives 1 and 2, but approximately half the magnitude for Alternative 3. The primary adverse impact would be alteration of wetland/riparian areas by the discharge of produced CBM water. During production, wetland/riparian areas are likely to expand in size, although increased water flow may also result in increased levels of erosion or sediment deposition, causing adverse impacts. As water production decreases towards the end of the Project, wetland/riparian areas would contract, returning to pre-Project sizes. Areas of excessive erosion or sediment deposition may cease to function as wetland/riparian areas. All of these changes in the extent of wetland/riparian areas would provide opportunities for aggressive species, including noxious weeds, to invade disturbed areas.

Wildlife

Unavoidable direct and indirect adverse effects would occur under each of the four alternatives. The extent of change in water quality, flow, sedimentation, and habitat from discharge of CBM produced waters into surface drainages would be greatest under Alternative 1, followed by Alternative 2B, Alternative 3, and Alternative 2A, respectively. Aquatic species would be affected as mentioned above, and restoration of biodiversity in sub-watersheds affected by CBM produced water discharge would require an extended period of time and would include controlling the spread of exotic species that may occur during the project. Native species may have difficulty recolonizing historical habitats should exotic species invade them, or if populations decline below levels that could sustain population growth.

Threatened, Endangered, or Sensitive Species

Unavoidable direct and indirect adverse effects to special-status wildlife species would occur under each of the four alternatives. These include loss of some foraging and nesting habitats. Unavoidable adverse effects to special-status species of plants could result from construction and vehicular trampling of plants.

Land Uses

For any of the alternatives, there would be unavoidable short-term, adverse indirect effects to the land uses on properties adjacent to the Project-related facilities, resulting from the from noise, traffic, and dust generated by the project-related vehicles and equipment, primarily during the construction-related activities within the Project Area.

Transportation

For any of the alternatives, there would also be unavoidable long-term indirect adverse effects to the properties adjacent to the major access roads within the Project Area due to generation of increased traffic, noise, and dust from the project-related vehicles.

Quality of Life

Effects to quality of life may occur depending on an individual's point of view. For those that prefer the solitude and natural setting, their quality of life would be affected for the life of the Project. Additionally, not drilling Federal wells now may result in future negative production rates on Federal minerals, due to depletion of minerals from drilling on State and private lands.

Irreversible and Irretrievable Effects

An irreversible or irretrievable commitment of resources would occur when resources would be consumed, committed, or lost as a result of the project. The commitment of resources would be irreversible if the project stated a process (chemical, biological, or physical) that could not be stopped. As a result, the resource or its productivity or its utility would be consumed, committed, or lost forever. Commitment of a resource would be considered irretrievable when the project would directly eliminate the resource, its productivity, or its utility for the life of the project and possibly beyond.

No irreversible or irretrievable effects would occur to air quality, visual or noise resources. The following is a listing of the effects that would occur to the other resources analyzed in this EIS.

Irreversible Effects

- Removal of natural gas
- Transfer of groundwater to surface water

Irretrievable Effects

- Loss of vegetative cover for several years until reclamation is successful
- Loss of riparian vegetation over life of Project
- Loss of portions of big game winter range over life of Project
- Loss of sensitive species habitat
- Loss of livestock forage for several years until reclamation is successful